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PENNSYLVANIA GEOLOGY

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THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 10/1

COMMONWEALTH OF PENNSYLVANIA
Dick Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Pinnacle weathering developed on limestone along I-81 in Cumberland County, 5 miles southwest of Carlisle. Photo courtesy of Pennsylvania Historical and Museum Commission.

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FEBRUARY 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

THE NUMBERS GAME

Even as we are participating in an assessment of our future computer needs, I wonder about the trend to force geologic observations into the numbers needed to satisfy the monster machines. It wasn't always that way. If one reads the classic tomes that were issued by the geologic greats of the 1800's and early 1900's there are certain qualities of communication, inspiration, and romance in the descriptions they offered which are missing in today's cold, quantitative reports. Were those geologic investigators of yesteryear less the scientists for their style of reporting? Do the hard numbers we pursue today throughout our society necessarily serve us better?

Of course, quantification is a valuable tool, but hopefully not at the expense of qualitative expression, the beauties of nature, and human values. The quantification which pervades our society has brought us such recent "classics" as the decision by a federal agency not to initiate flood controls along the Susquehanna River due to computed "unfavorable cost-benefit ratio!" And there are also the management techniques of calculated budget-productivity ratios which tend to overlook the elements of quality and of response to human needs; shades of Charlie Chaplin's "Modern Times."

As we move to further utilize the computers, I would hope that they will be our servants, and not our masters. As we function in an era which calls upon us to respond by numbers, my hope is that we shall not lose our appreciation for quality, beauty, and the needs of people and nature.

Arthur A. Socolow

Some Interesting Notes on the Minerals Industry of Pennsylvania

A recent report prepared by the U.S. Bureau of Mines, updated in part by the Pennsylvania Geological Survey, provides some interesting information concerning the mineral industry of Pennsylvania.

The mining industry in Pennsylvania presently directly employs approximately 45,000 persons. Although they represent only a small percentage of the State's population, these workers are a vital force in our society. Together they produce a variety of minerals needed to support the manufacturing and construction industries which are so essential to our way of living.

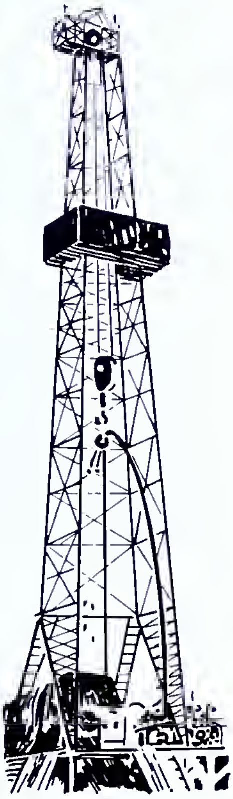
Statistics for 1977 show that Pennsylvania ranks first among the states in the production of anthracite coal and stone, 2nd in lime, masonry cement, and fire clay, 3rd in portland cement, bituminous coal, and peat, 6th in natural abrasives, 7th in crude mica and zinc, 9th in common clay, 10th in kaolin, iron ore, and industrial sand and gravel, 13th in copper, 15th in construction sand and gravel, 22nd in natural gas liquids, 24th in crude petroleum production, and 27th in the value of semi-precious stones.

Bituminous coal accounted for over 70 percent of the $3.2 billion credited to mineral production in the State in 1977. Plans by industry for new surface and underground mines should increase those figures in the future. Although Washington, Indiana, and Clearfield were the three leading counties in the State in bituminous coal production in 1977, Greene County, with 12 major underground mines planned, may become the "numero uno" county for coal production in the future.

Over half the coal consumed annually in Pennsylvania is used to generate electricity, placing the State third in the Nation as a producer of electric energy. Pennsylvania's 1975 installed electrical capacity showed coal accounting for 63 percent of the total, oil 18 percent, nuclear 14 percent, and hydro 5 percent. However, power production does not necessarily correspond to the installed capacity, and owing to fuel costs, shutdowns, repairs and various maintenance stoppages, coal actually supplied 77 percent of the State's electric generating needs, nuclear 15 percent, oil 7 percent, and hydro 1 percent. Apparently the State's generating capacity is evolving toward a coal-nuclear mix from its former coal-oil-gas-combination.

Production of anthracite coal in 1977 was approximately 6 million tons, with brighter prospects for this industry indicated in a recent report by Berger Associates who predict the potential market may reach 17 million tons by 1990. One electric power company recently had under consideration a large-scale open pit mining system within the Pennsylvania anthracite region.

Since 1859, the year the Drake well, this Nation's first oil well, was drilled in Pennsylvania, over 240,000 oil-producing wells have been drilled in the State. Of these, 28,400 were still producing in 1977 at an average rate of 0.26 barrel per day, making Pennsylvania the 24th leading producing state in the Nation, even though most of the wells fall into the category of "stripper wells." (A stripper well is one which produces less than 10 barrels per day.)



Natural gas provided 17 percent of the State's energy requirements in 1975. Of the gas used in the state, residential customers use about 42 percent, industry 40 percent, commercial 15 percent, and other uses the remaining 3 percent. At the end of 1977, the number of gas producing wells in Pennsylvania approximated 17,900. Leading counties both in gas production and new gas wells drilled were Indiana, Westmoreland, Jefferson, and Clearfield Counties. Although consumption of natural gas decreased somewhat between 1972 and 1975, it began a comeback in 1976, and should increase further in the future due to: (1) additional supplies being made available by transmission companies; (2) the availability of liquefied natural gas; (3) more competitive pricing; (4) the possibility of discovering gas in Lake Erie; (5) the technology of degasification of virgin coal seams, and; (6) technology related to the development of organic-rich shales of Devonian age in Pennsylvania.

The five most energy-intensive industrial groups in Pennsylvania are: (1) stone, clay, and glass; (2) primary metals; (3) petroleum and coal; (4) paper and allied products; and (5) rubber and plastics. Collectively, these industries use almost 65 percent of Pennsylvania industry's share of energy, although they employ only about 26 percent of the State's manufacturing workers. While a decrease in energy flow to these energy-intensive industries would have little immediate effect on statewide employment, production shortages in these industries would have a devastating effect on almost every other industry. Virtually every industry in Pennsylvania relies on the products of at least one of these industries as an input into its own production processes.

Persons interested in obtaining a free copy of the U.S. Bureau of Mines report should request it from Publications Distribution Branch, U.S. Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, PA 15213. The report is identified as SMP-37, titled "Minerals in the Economy of Pennsylvania," and is dated September, 1978.

Survey Offers National Map Information

The Pennsylvania Geological Survey has formalized an agreement which will greatly increase its ability to provide the public with information on the availability of maps, aerial photographs, space images, and other cartographic products produced by federal, state and private agencies. Pennsylvania is one of the first eastern states to sign a cooperative agreement to join with the National Cartographic Information Center (NCIC) headquartered at the U.S. Geological Survey in Reston, Virginia.

The NCIC is specifically dedicated to hunt for, organize, and distribute information on the existence and availability of cartographic products. At the Pennsylvania Survey this cartographic reference material will be available through the Survey's geology library. A total of 18 types of multi-use maps and charts are accessible through the NCIC system, as well as five kinds of geodetic survey data and four types of aerial and space imagery.

The eventual plan is to tie the geologic library in Harrisburg by computer terminal to the main NCIC computers in Reston and at Sioux Falls, South Dakota.

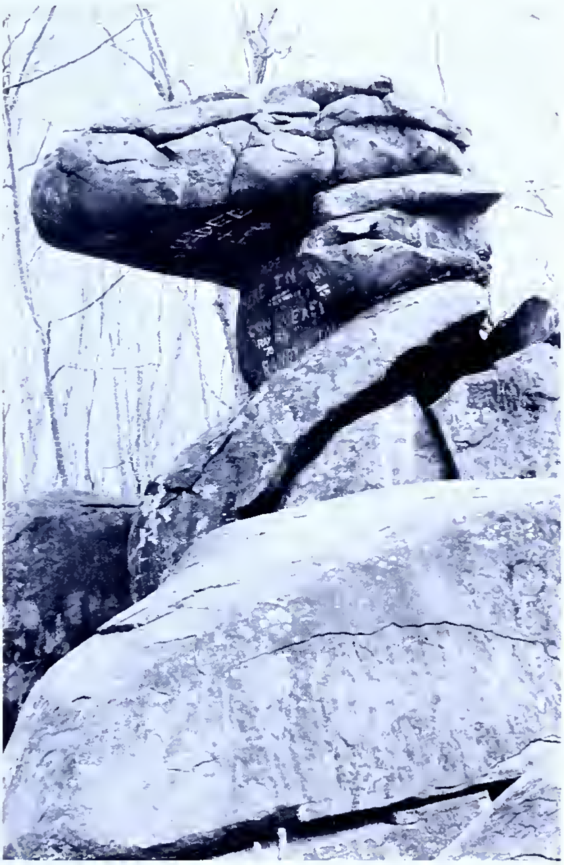
The public is invited to utilize the new cartographic information services at the Survey library, 916 Executive House, Second Street, Harrisburg. Mail and Phone inquiries are welcome. It is anticipated that map information assistance can benefit all who make use of any of the various types of maps and imagery, including foresters, farmers, sportsmen, planners, engineers, conservationists, and property owners.

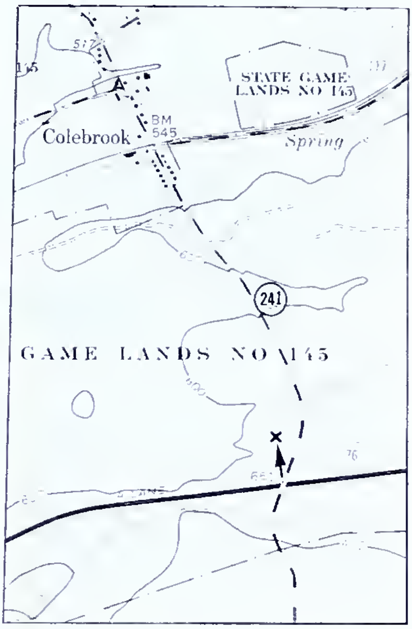
A DIABASE DINOSAUR

by William H. Bolles[1]

A wooded area southeast of Colebrook in Lebanon County contains a unique geologic feature. An unusual example of weathering of a diabase "sheet" which crosses eight of the southeastern counties of the Piedmont physiographic province has produced a configuration that resembles the head of a dinosaur.

The diabase intrusion was once a molten mass of rock called magma which slowly cooled and solidified at depth forming dikes, sills and sheets. Erosion has removed the overlying rock layers and the hard, dense diabase forms ridges and hills that exhibit a striking





DINOSAUR ROCK — Located in the woods north of Lawn in Lebanon County is this unusual example of the weathering of diabase topographic contrast between the soft, red shales and siltstones of the surrounding valley lowlands.

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[1] Dept. of Education

In some places where the diabase is quarried the term "black granite" has been used to describe the rock. However, since granite is a rock composed of over 50 percent quartz, diabase can't be called granite since it contains very little, if any, quartz. An old term used to refer to the diabase was "trap rock" which probably originated from the German, "Treppe," meaning steps. The term was applied to the rock by quarrymen in Germany because it could be quarried in large blocks due to its rectangular jointing and could be worked from the face of a quarry in a series of steps. The common local term in referring to the diabase is "ironstone" which came about due to the extreme hardness of the rock and its dark color as well as the fact that in some areas the diabase will give off a clear bell-like tone when struck with a hammer, giving rise to another name, "ringing rocks." Elsewhere in the Commonwealth, diabase has contributed to the mineral wealth of the state as a source rock for building stone and crushed stone.

USGS To Celebrate 100th Year

In 1979, the U.S. Geological Survey, established by Congress in 1879, will observe its 100th anniversary. The original Act provided for " the classification of the public lands and the examination of the geological structure, mineral resources, and products of the national domain." Additional acts and statutes expanded this authorization to include examinations outside the national domain, and for gaging the streams and determining the water supply of the United States.

To carry out its missions, the USGS employs more than 13,000 scientists, engineers, technicians and administrative support personnel throughout the United States and in some foreign countries. Major facilities include the National Center, Reston, Va; and Regional Centers at Denver, Colorado and Menlo Park, California. Special services and investigative facilities include the EROS (Earth Resources Observation Systems) Data Center, Sioux Falls, SD; Center for Astrogeologic Studies, Flagstaff, AZ; Hawaiian Volcano Observatory, HI; and Gulf Coast Hydroscience Center, Bay St. Louis, MS.

Dr. H. William Menard, the present and 10th director of the USGS in its 100-year history, said, "While centennial activities will reflect Survey contributions to the nation's past growth, they will serve to focus on the challenges of the future to the earth science community. To make decisions for rational use of lands, to explore for and develop our resources wisely, to mitigate the effects of geologic hazards — these and other related problems are formidable and sobering challenges to all Americans. In particular, however, heavy burdens of responsibility will be placed on earth scientists, for sound knowledge about the Earth and natural processes are basic to the solution of these critical resource and environmental problems."

"For the Survey," Menard said, "its centennial will be a time for re-dedication and re-commitment to the goal of those who preceded us — the pursuit of earth science knowledge in the public interest."

The USGS will mark its centennial year with commemorative programs, symposia, special publications, and exhibits. Among the planned USGS centennial activities:

"Centennial Day" ceremonies at the Survey's National Center, Reston, Va., and other major facilities, on March 2 and 3, featuring guest speakers and public tours.

A USGS International Centennial Symposium in October will examine the challenges being faced by the USGS and Geological Surveys of other countries in meeting global requirements for resources for the coming century.

USGS exhibits at Survey, federal, or other facilities in and outside the Washington, D.C. area, including a display of earth science maps at the Library of Congress, and a history of the Survey in photographs at the Survey's national and regional centers.

Special publications to include a four-volume history, "Minerals, Lands, and Geology for the Common Defense and General Welfare," a single-volume history of the USGS, and publication of "Maps for America," covering cartographic products of the USGS and other agencies.

A special postal cancellation to be used during the period of March 1 to August 31 in 10 major cities and at large USGS centers.

Symposia and technical sessions treating USGS current and planned activities to be held at annual and regional meetings of professional geological organizations.

The Pennsylvania Geological Survey, founded in 1836, extends birthday greetings and good wishes to its younger, brother agency.

* * *

How Many Minerals In Pennsylvania

by Robert C. Smith II
John H. Barnes

Well, quite frankly, we don't know exactly, but a good estimate would be about 500. What we do know is that 309 have been carefully verified up to the end of 1978. Verification of many of the other mineral species will probably require unusually sophisticated techniques.

Few states have such carefully verified lists of mineral species. Pennsylvania, however, has been blessed with a long line of excellent mineralogists, the three most outstanding being F.A.L.K.W. Genth (*Mineralogy of Pennsylvania,* 1875), S.A. Gordon (*Mineralogy of Pennsylvania,* 1922), and Arthur Montgomery (*Mineralogy of Pennsylvania 1922-1965,* 1969). Because of their high standards of scientific accuracy, it has been relatively easy to prepare up-to-date lists that include species more recently discovered, such as the lists presented by R.W. Grant, *Keystone Newsletter,* August, 1974; A.R. Geyer and others, *Mineral Collecting in Pennsylvania,* 1976; R.C. Smith II, *The Mineralogy of Pennsylvania 1966-1975,* 1978; and the one below.

Active research on Pennsylvania's minerals for purely mineralogic purposes is now being conducted at no less than six major research institutions. One result of this research has been the identification and naming of three new species in the past few years; desautelsite, downeyite, and matulaite. With this interest and the technical facilities at their disposal, we can expect the Pennsylvania list to grow at a slow, steady rate for many years to come. The Pennsylvania Geological Survey encourages this research and hopes that additional species will be verified by at least two independent methods and that mineralogists will be cautious in their identifications. It is hard to say whether more misidentifications are perpetrated by amateur or professional mineralogists! For example, the first author of this article knows of six professionals, including himself, who have been fooled into misidentifying ferroan dolomite as ankerite. Even the X-ray diffraction standard file makes this mistake.

Two forthcoming Bureau publications will describe the mineral occurrences that have been the source of many additions to the Pennsylvania list in recent years. One deals with the minerals that form as a result of underground fires in anthracite mines and waste piles. The other describes the copper-uranium occurrences and minerals in the Picture Rocks and Sonestown 7½′ quadrangles. These reports demonstrate the relationship between mineral identification and man's environment.

PENNSYLVANIA MINERAL SPECIES AS OF DECEMBER 31, 1978

acanthite
actinolite
albite
allanite
alloclasite
allophane
almandine
alunite
alunogen
analcime
anatase
ancylite
andersonite
andesine
andradite
anglesite
anhydrite
anorthite
anthophyllite
antigorite
apophyllite
aragonite
*arsenolite
arsenopyrite
artinite
augite
aurichalcite
autunite
azurite
"babingtonite"
*bararite
barite
bastnaesite
beraunite
*berndtite
beryl
beta-uranophane
bianchite
billietite
biotite
bismuthinite
bismutite
boehmite
boltwoodite
bornite
*boussingaultite
brochantite
brookite
brucite
bytownite
cacoxenite
calcite
cancrinite
carbonate-fluorapatite
carnotite
*cassiterite
celestine
cerussite
chabazite
chalcanthite
chalcocite
chalcophyllite
chalcopyrite
chamosite
chervetite
chevkinite
chloritoid
chondrodite
chromite
chrysocolla
chrysotile
clausthalite
clinochlore
clinohumite
clinozoisite
cobaltite
coffinite
conichalcite
copiapite
copper
cordierite
corkite
cornubite
corundum
covellite
crandallite
*cryptohalite
cryptomelane
cuprite
datolite
desautelsite
descloizite
diaspore
dickite
digenite
diopside
djurleite
dolomite
*downeyite
dravite
dumortierite
enargite
enstatite
epidote
epsomite
erythrite
fayalite
ferrimolybdite
ferroaxinite
ferrocolumbite
fluorapatite
fluorite
forsterite
fourmarierite
francevillite
gahnite
galena
gersdorffite
gibbsite
gismondine
glauconite
goethite
gold
goslarite
graphite
greenockite
grossular
gypsum
halite
halloysite
halotrichite
harmotome
heazlewoodite
hedenbergite
hematite
hemimorphite
*herzenbergite
heulandite
hexahydrite
hinsdalite
hornblende
huntite
hyalophane
hydromagnesite
hydroxyl-apatite
hydrozincite
hypersthene
idaite
"illite"
ilmenite
ilvaite
jarosite
jordanite
kammererite
kaolinite
kasolite
kieserite
kyanite
labradorite
langite
lansfordite
lanthanite
laumontite
lepidocrocite
liebigite
linarite
lizardite
mackinawite
magnesiochromite
magnesite
magnetite
malachite
manganaxinite
marcasite
margarite
marialite
*mascagnite
matulaite
meionite
melanterite
mesolite
meta-autunite
metanovacekite
metatorbernite
metatyuyamunite
meta-uranocircite
metazeunerite
microcline
millerite
mimetite
molybdenite
molybdenite-3R
monazite
montmorillonite
morenosite
*mullite
muscovite
natrolite
nepheline
nesquehonite

nontronite
nsutite
oligoclase
olivenite
opal
*orpiment
orthoclase
orthoferrosilite
*ottemannite
palygorskite
paragonite
pectolite
pentlandite
phillipsite
phlogopite
phosphuranylite
pickeringite
*picromerite
piemontite
pigeonite
plumbojarosite
posnjakite
*potash alum
powellite
prehnite
pseudomalachite
pumpellyite
pyrite
pyroaurite
pyrolusite
pyromorphite
pyrope
pyrophyllite
pyrrhotite
quartz
*realgar
renardite
retgersite
riebeckite
rockbridgeite
"rosasite-(Mg)"
rozenite
rutile
*salammoniac
safflorite
"safflorite-(Fe)"
sauconite
scheelite
schorl
schroeckingerite
*selenium
sepiolite
serpierite
siderite
sillimanite
silver
sklodowskite
skutterudite
smithsonite
spessartine
sphalerite
spinel
starkeyite
staurolite
stilbite
stilpnomelane
strengite
strontianite
sulfur
susannite
*syngenite
talc
tennantite
tetrahedrite
thaumasite
*thenardite
thomsonite
thorianite
thorite
thorogummite
titanite
tochilinite
torbernite
tremolite
*tschermigite
turquoise
tyrolite
tyuyamunite
uraninite
uranophane
uranospinite
uvarovite
vanadinite
vandendriesscheite
variscite
vermiculite
vesuvianite
violarite
vivianite
*voltaite
wavellite
weeksite
wollastonite
wolsendorfite
wulfenite
wurtzite
zaratite
zircon
zoisite

*Materials recently formed in Pennsylvania in environments such that the first author and some other mineralogists regard them as not fulfilling the "naturally occurring" clause of most classical definitions of a mineral. Other mineralogists, including the second author, feel that they do fit the definition of a mineral. For additional information on these minerals, the reader is referred to Finkelman and others, 1974, *Observations on minerals from burning anthracite seams and culm in Pennsylvania* (Geol. Soc. America Abstracts w. Program, v. 5, n. 1, p. 27-28); Finkelman and Mrose, 1977, *Downeyite, the first verified natural occurrence of* SeO_2 (Am. Mineralogist, v. 62, p. 316-320); and Finkelman, 1978, *Release of trace elements from a burning bituminous culm bank* (USGS Open File Rpt. 78-868).

COASTAL MAPPING HANDBOOK, edited by M. Y. Ellis

A new publication dealing with maps and related services has been released by the National Oceanic and Atmospheric Administration in cooperation with the United States Geological Survey. The handbook should help planners and managers of coastal programs to determine their mapping requirements, and to be aware of various map products so that they can select the best maps and charts for their needs. The handbook provides basic information on maps, mapping procedures and sources of technical assistance.

Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Stock No. 024-001-03046-2. Price: $5.25.

THE DEVIL IN PENNSYLVANIA

by Alan R. Geyer

Dr. Thomas R. Beveridge, a long-time friend now deceased, published an inventory of geologic features for the State of Missouri.* While "Tom" was State Geologist of Missouri (1955-1964), we talked of a raft trip down the Missouri River, fishing for those giant catfish and geologizing as we drifted. His magnificant book reflects this and other similar trips he must have taken during those years. I wish I could have been along.

An intriguing chapter, titled *The Devil in Missouri*, appears in his work. What "Tom" found in Missouri, is also true in Pennsylvania. His story follows, changed slightly to fit our Commonwealth.

Pioneer Pennsylvanians, largely of Scotch-Irish and German backgrounds, were preoccupied with the Devil, largely as a result of Calvinistic teachings. This Devilish influence is in sharp contrast to the western United States where the Latin-American settlers predominated and features named commonly alluded to angels and Heaven.

The following list of over 30 geologic features named for this "fellow" has been compiled from published reports and topographic maps. It is definitely not complete but represents the majority of Pennsylvania's geologic features named for creations, haunts, and physical parts of the Devil.

---

*Beveridge, Thomas R. (1978), *Geologic Wonders and Curiosities of Missouri*; Missouri Division of Geology and Land Survey, Educational Series No. 4, 451 p.

DEVILS DEN,

ADAMS COUNTY

DEVILISH HAUNTS IN PENNSYLVANIA

NAME	TYPE OF FEATURE	LOCATION
Devil Alex Hollow	Stream valley	Franklin County, Scotland Quad
Devil Head	Rock promontory	Berks County, Manatawny Quad
Devils Backbone	Ridge	Erie County, Albion Quad
Devils Course	Stream	Dauphin County, Manada Gap Quad
Devils Den	Erosional remnant	Adams County, Gettysburg Quad
Devils Den	Rock promontory	Elk County, Ridgeway Quad
Devils Den	Rock promontory	McKean County, Smethport Quad
Devils Den Cave	Boulder cave	Adams County, Gettysburg Quad
Devils Den Cave	Sinkhole cave	Westmoreland County, Derry Quad
Devils Elbow	Hill	Centre County, Snow Shoe SE Quad
Devils Elbow	Meander	Clearfield County, Devils Elbow Quad
Devils Elbow	Stream valley	Tioga County, Morris Quad
Devils Elbow	Hill	Union County, Weikert Quad
Devils Feather Bed	Stream valley	Northumberland County, Riverside Quad
Devils Garden	Boulders	Sullivan County, Eagles Mere Quad
Devils Hole	Stream valley	Elk County, Wildwood Fire Tower
Devils Hole	Stream valley	Monroe County, Buck Hill Falls Quad
Devils Hole	Rock shelter	York County, Red Lion Quad
Devils Hole Caves	Boulder caves	Lancaster County, Morgantown Quad
Devils Hole Creek	Stream	Monroe County, Buck Hill Falls Quad
Devils Hole Run	Stream	Columbia County, Benton Quad
Devils Hump	Ridge	Berks County, Boyertown Quad
Devils Potato Patch	Boulder field	Northampton County, Palmerton Quad
Devils Pulpit	Rock promontory	Carbon County, Palmerton Quad
Devils Punchbowl	Plunge pool (glacial)	Susquehanna County, Susquehanna Quad
Devils Racecourse	Boulder field	Dauphin County, Enders Quad
Devils Racecourse	Boulder field	Franklin County, Iron Springs Quad
Devils Run	Stream	Clearfield County, Clearfield Quad
Devils Run	Stream	Franklin County, Blue Ridge Summit Quad; MD-PA
Devils Wall	Ridge	Carbon County, Palmerton Quad
Hells Kitchen	Stream valley on mountain slope and rock promontories	Luzerne County, Freeland Quad

DEVILS WALL, CARBON COUNTY

EARTH SCIENCE TEACHERS' CORNER

PILOT TESTING OF CRUSTAL EVOLUTION EDUCATION PROJECT MATERIALS IN PENNSYLVANIA

Thirty-one Pennsylvania teachers of Earth and Space Science will be involved in the pilot testing of the Crustal Evolution Education Project (CEEP) curriculum materials. They will be among 205 other teachers at 12 test centers across the country who will be participating in the evaluation of a total of 64 modules.

The CEEP materials were developed under a grant from the National Science Foundation awarded to the National Association of Geology Teachers and Edward C. Stoever, Project Director, at the Southeast Missouri State University. The purpose of the project was to develop materials related to current research into the composition, history, and developmental processes of the earth's crust and the applications of this knowledge to man's activities. A major thrust of the project is to shorten the time lag between ongoing research and its translation into secondary school curriculum materials which are highly appealing to students and readily usable by teachers.

During the past year the instructional modules were developed at six Development Centers involving 52 research scientists and 83 teachers. Accompanying each module is a Teacher's Guide; the pilot teachers will also be evaluating the effectiveness of these Teacher's Guides.

Most test centers around the country consist of 12 to 15 pilot teachers and a center director; however, due to the large student enrollment in Earth and Space Science in Pennsylvania that center was asked to acquire double the number of teachers. The Pennsylvania test center is directed by William H. Bolles, Department of Education; the National testing program is directed by Victor J. Mayer at the Ohio State University. The pilot teachers are: Theodore E. Aiken, Pennfield Junior High School; William L. Bechtel, Selinsgrove Area High School; John E. Biddle, Upper Dublin Area High School; Robert Caruse, York County AVTS; Peter C. Christ, Owen J. Roberts High School; Vincent DiDonato, Huntingdon Junior

High School; Dennis W. Dull, Chambersburg Area High School; Deborah DuBoise Ehleiter, Beverly Hills Junior High School; William Eunson, Interboro High School; James J. Fackler, Reynolds Junior High School, David B. Fluri, F.D. Roosevelt Middle School; Peter Gamber, Hershey Junior High School; Anthony A. Geno, Drexel Hill Junior High School; Thomas C. Hertel, Iroquois High School; Helen S. Kelly, Vandergrift Junior High School; Thomas P. Knorr, Pen Argyl Junior High School; Jennie Melisis, Monessen Junior-Senior High School; John P. Mentzer, Big Spring High School; Robert T. Mintmier, Westmont Hilltop Junior High School; Virgil Moraca, Shade Central City School; Alfred C. Palmer, Springton Lake Junior High School; Wallace S. Penrod, Garfield Junior High School; Joseph Ptacin, Sunbury Middle School; Frank Pipik, Phillipsburg Junior High School; Fred Ramin, A.G. Curtin Junior High School; John Rogers, Elizabethtown Area High School; Anthony M. Russell, South Hills High School; Robert J. Thomas, Linton Intermediate High School; Elden F. Walthour, Monroeville Junior High School; Gary T. Zelinske, Lebanon Senior High School; and James S. Zuck, Donegal High School.

At the conclusion of the testing and evaluation program the most successful of the modules will be published by Ward's Natural Science Establishment, Inc. They hope to have a few modules ready to distribute at the National Science Teachers convention at Atlanta in March.

William H. Bolles
Science Education Adviser
Department of Education

The York Rock and Mineral Club will hold its Tenth Annual Mineral and Gem Show on Saturday, April 7 and Sunday, April 8, 1979 at the Manchester Township Fire Company #1 in the Manchester Township Building, Emigsville, PA. The firehouse is located in Emigsville, PA on Route 181, going North from York, PA.

Show hours are Saturday, April 7 – 10 AM to 9 PM and Sunday, April 8 – 10 AM to 6 PM. Admission – $.75; children under 12 free.

SURVEY ANNOUNCEMENTS

WORK BEGINS ON GEOLOGIC GUIDE TO THE APPALACHIAN TRAIL

The preparation of a guide on the *Geology of the Appalachian Trail in Pennsylvania* has been started by J.P. Wilshusen, Environmental Geology Division.

The Appalachian Trail enters the state at the Delaware Water Gap in Monroe County, traverses three physiographic provinces over a distance of more than 200 miles, and crosses the Maryland line at PenMar, near Waynesboro in Franklin County.

Utilizing maps, photographs and text, the guidebook will describe geologic features along the trail as well as those that can be seen from the many vantage points on ridge crests along the trail. A geologic map of the trail at a scale of 1:250,000 (1 inch = 4 miles) will have designated locations keyed to text descriptions accompanied by detailed map insets and photos.

Rock formations traversed by the Trail in Pennsylvania range from Cambrian (575 to 500 million years old) to Jurassic Age (180 to 135 million years old) with a long geologic record of outstanding events, extending through the Pleistocene ice ages, into the present. All rock types, including sedimentary, metamorphic and igneous, are encountered. All in all, an interesting geologic story awaits the reader and the trail hiker.

Geologists At Work

These staff geologists are neither praying, nor bowing to the Director, nor looking for their contact lenses. They are working on the final stages of a geologic map for which the basic data was originally collected through geologic investigations and measurements in the field. The results of our field work, however, are always made available to the public by published maps and reports. In the accompanying photo, the geologists were in the process of checking the accuracy of drafting compilation of a large geologic map which lies under the transparent tracing paper upon which they are kneeling. The geologic map will soon be on its way to the printer.

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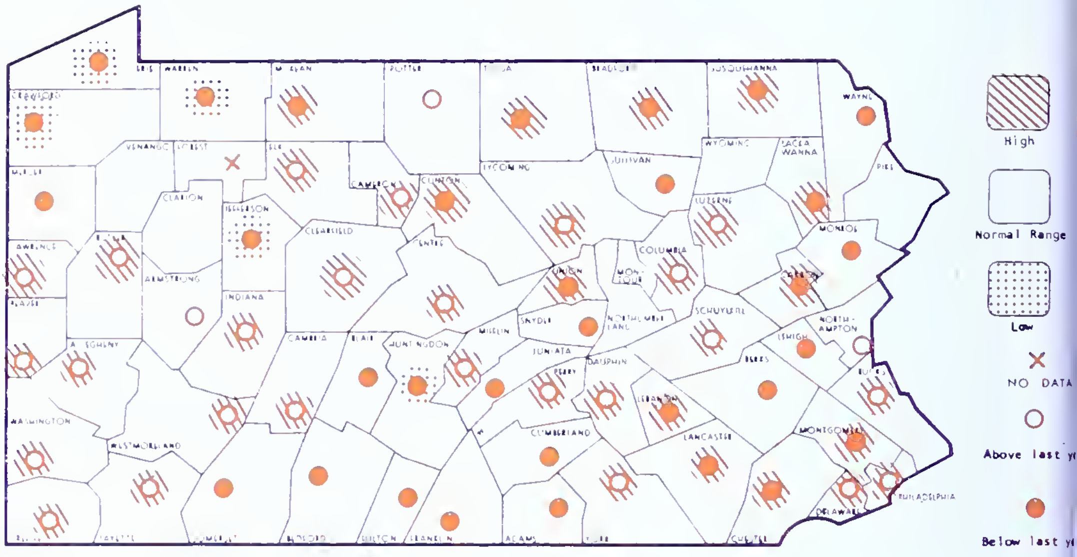

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COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Not a pothole; just a sinkhole under Bullfrog Valley Road, near Hershey. This driver learned that sinkholes do have an impact upon man (See article, page 2). Photo courtesy of William H. Bolles.

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APRIL 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

THE LESSONS WE LEARN

Many years ago I was told that Harrisburg was utilized by industry and the government as a testing area for new products, services, and even movies. It appears that the testing has been extended considerably further, and includes such unplanned phenomena as floods and nuclear disasters. These traumatic events are, of course, too serious to be considered frivolously; I mention them here because we have just been provided with a reminder that there is a continued need to have on hand detailed maps and basic data on the geology, groundwater resources, and topography of all areas of our state.

At the very outset of the nuclear problem, there was a run on our supply of topo maps of the problem area as a variety of state and federal disaster and environmental agencies rushed to prepare appropriate response plans for the problem.

Then there was a call for all available groundwater data in a broad region of central Pennsylvania in order to evaluate the adequacy of water supplies for the various evacuation centers which were being planned.

As concern mounted over the possibility of a reactor core meltdown, attention was focused on the groundwater conditions at the plant site, as well as the bedrock geology at the site. The extent of health and environmental impacts of a potential meltdown were dependent in large measure on the nature of the bedrock and groundwater characteristics beneath the nuclear plant site.

Fortunately, we had available the required topographic, geologic, and groundwater maps and data. These are not data that can be prepared instantly in a crisis situation; our maps and reports are the result of detailed work by this agency over many, many years.

The lesson that applies directly to us from this tragic event is that we must keep on with our goal of completing and maintaining coverage of the entire state with up-to-date, detailed maps and data on the geology, topography, and groundwater resources. We hope for no more disasters of any type, but we must always be prepared; neither man nor nature is infallible. Fortunately, the very same data whose importance I stress here, also serves to support our economy, protect our environment, and maintain our way of life. There is a satisfaction in recognizing that our efforts and products are important; we are anxious to get on with the job.

Arthur A. Socolow

A Sinkhole Swallows A Road Before Our Very Eyes

by Alan R. Geyer and Arthur A. Socolow

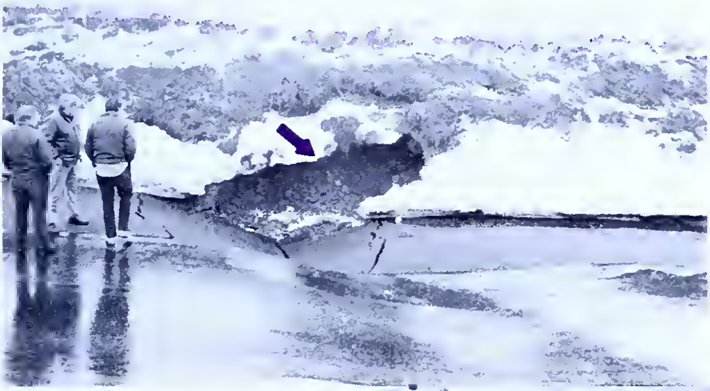
If you wanted to watch a sinkhole actually develop, a rare sight of geology in action, Bullfrog Valley Road near Hershey was the place to be between Saturday, February 24 and Friday, March 2, 1979. A series of three photos shown here illustrates the progression of the sinkhole enlarging and the resulting damage progressively increasing. Starting as a depression at the side of the road, the road then collapsed. As one ambitious driver found out (by going around a barracade) the road was impassable. This is but one contemporary example of a long history of sinkhole development in Pennsylvania.

Sinkholes at best are a nuisance. To the farmer, they represent an area of the field that cannot be plowed, either too wet or an open hole. In some cases several acres are involved on one farm. To the borough or township, sinkholes often represent a large unexpected expenditure of money to repair the damage. To the home owner, sinkholes have meant loss of property, money, and even life.

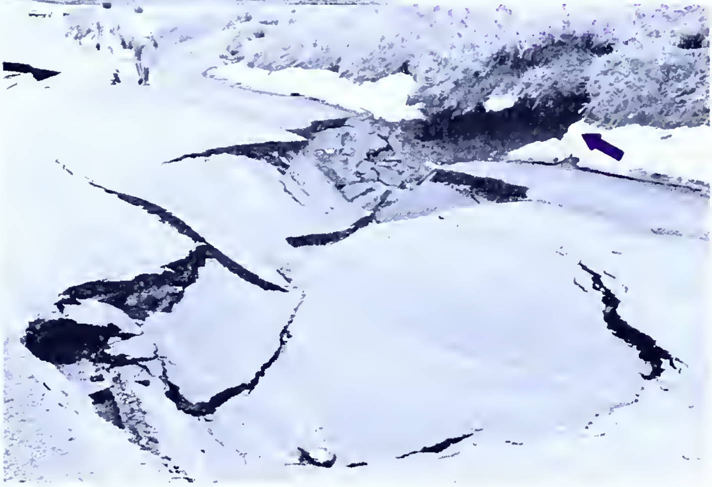
What are sinkholes? Sinkholes show up at the surface when the soil has moved down into holes in the underlying rock. Over the past several thousand years, percolating rainwater has seeped into the ground and has partially dissolved the limestone and dolomite bedrock. The solution of limestone and dolomite has taken place along pre-existing cracks or fractures in the bedrock, resulting in solution cavities in the rock that range in size from hair-line cracks to large caves (see sketch, page 4). This solution is a continuous process which takes place at an extremely slow rate, but the system of openings swallowing the soil today has long been in existence and for all practical purposes will not change in our lifetime. The origin of solution cavities, channelways, and caves in dolomite and limestone in Pennsylvania is complex and varies with rock type, attitude of the bedding, amount and orientation of fracturing, as well as rate and direction of groundwater movement.

Most sinkholes show up at the surface during or shortly after a prolonged period of rainfall. The rain may cause the soil and clay which has previously filled a cavity in the rock to be washed quickly down into the open spaces in the limestone, forming a depression

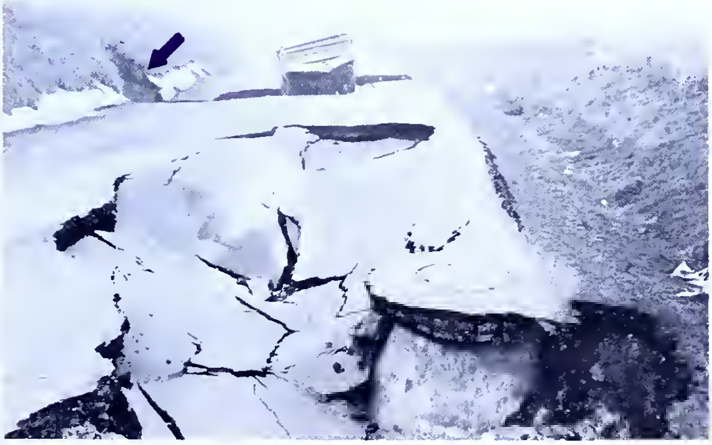
A sequence of photos shows several sinkholes developing after a rain in the Hershey Valley; Bullfrog Valley Road, Derry Township, Dauphin County. Photos by Wm. Bolles. Arrow points to the same location in each photo.



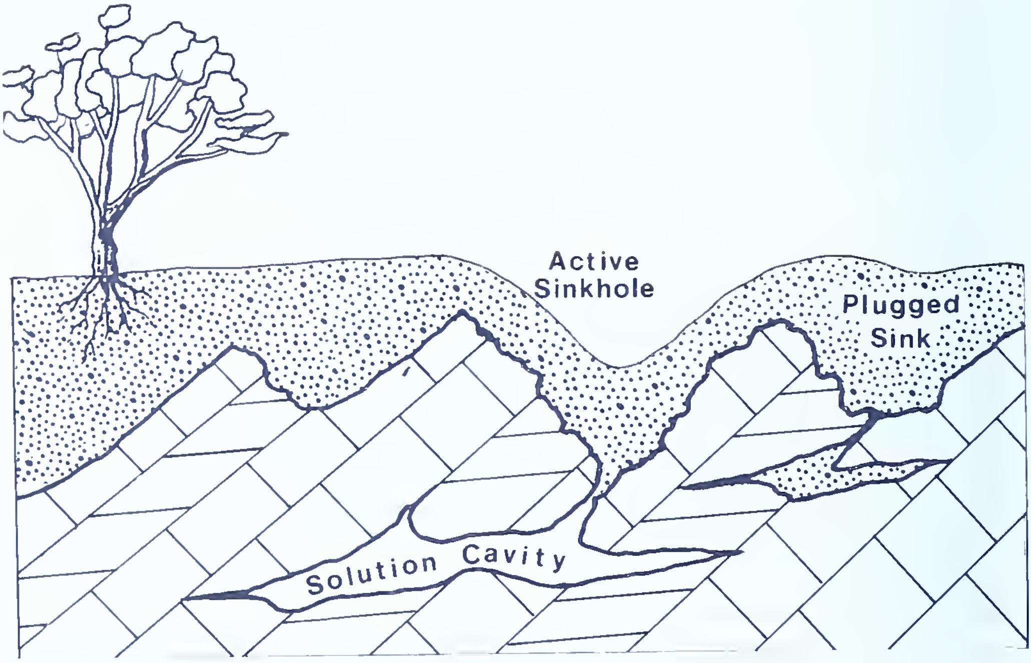
Monday,
February 26, 1979



Thursday,
March 1, 1979



Friday,
March 2, 1979

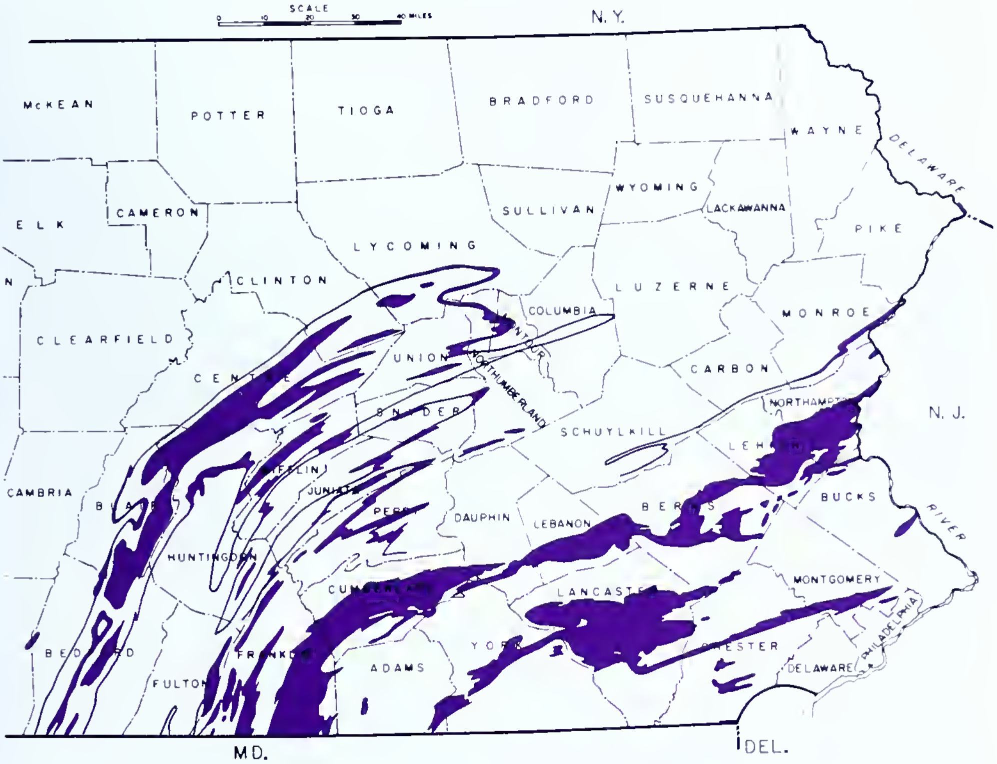


Sinkhole in the Lebanon Valley reportedly cost $90,000 to repair.

or sinkhole at the surface. In another situation the rain saturates the soil and rock which have existed as an arch over a subsurface opening, causing the arch to cave into the opening, forming a surface sinkhole. These are natural occurrences which happen often in Pennsylvania.

Man, in some cases, tends to accelerate the geologic, sinkhole-forming process. In urbanized areas, storm water runoff is often diverted by man into the soil overlying limestone bedrock. This water may effectively wash out soil plugs from solution cavities, resulting in surface collapse. Breaks in water mains and the use of french drains may also cause the same reactions. Large-scale pumping of groundwater from wells or quarries may lower the water table over an area which will cause the soils that had filled the solution cavities to wash out, resulting in surface sinkholes.

Where are sinkholes found in Pennsylvania? Wherever limestone occurs in Pennsylvania, you may expect to find sinkholes. However, some specific limestone valleys are more affected than others due to intense urbanization, rock type, and geologic structure. On the accompanying map these areas have been identified. Within each



Sinkhole in a residential backyard in the Lebanon Valley swallowed an entire car.

of these areas certain rock formations are most susceptible to cavern development and sinkholes. The Pennsylvania Geological Survey has studied these areas and their formations over the years and detailed geologic reports and maps have been published and are available.

Sinkholes in Pennsylvania generally range in diameter from a few feet to about 150 feet. In the southeastern part of the State the soil mantle involved in the larger of the sinks that have been investigated ranges from 50 to over 80 feet thick. In one sinkhole that was core drilled to 123 feet, the limestone and dolomite rocks were cavernous to a depth of 95 feet, with a 50-foot soil mantle present. Detailed groundwater studies in the Hershey and Lebanon Valley suggest that there are numerous fracture openings to 175 feet in depth.

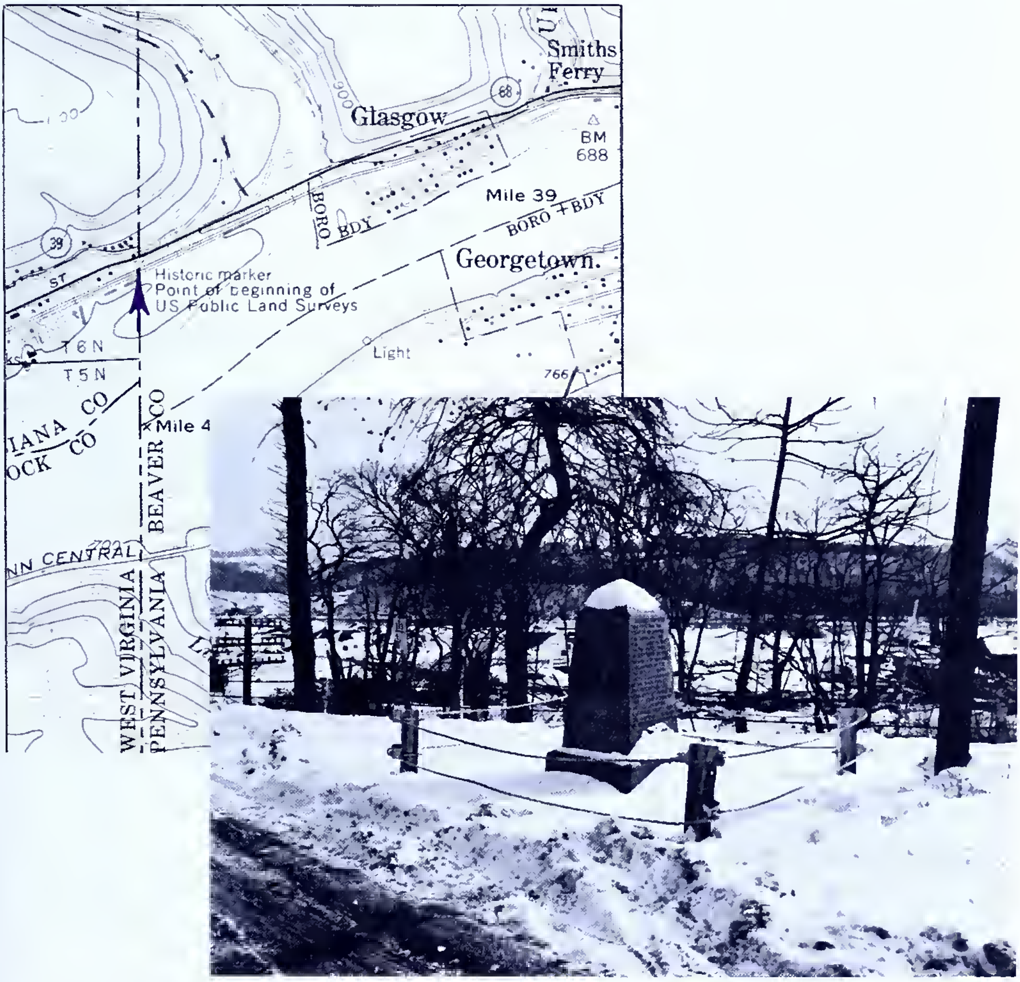
It is extremely difficult to detect openings in the rock prior to collapse. Drilling is excellent for the study of a small site but it is expensive when utilized on a large scale or regionally. Electrical resistivity profiles have proven effective for detecting some limestone openings but this method has depth limitations. To date, prior detection of sites likely to undergo surface collapse has not met with great success. The proper handling of storm water drainage in limestone terraines is the single most important precaution to reduce the likelihood of new sinkholes.

U.S. Public Land Survey Began In Pennsylvania

by Alan R. Geyer

The surveying of public lands in the United States had its beginning 1112 feet south of the monument along PA Route 68 west of Glasgow, Beaver County. On September 30, 1785, Thomas Hutchins, the first geographer of the United States, began his base line on the banks of the Ohio River.

This monument of St. Cloud (Minnesota) gray granite was originally erected in 1931 to mark the resurvey of the Pennsylvania-Ohio boundary line as established in 1786. In recent years the National Park Service has designated this site a registered National Historical Landmark. (Photo by Jesse Craft)



Continued Success In Gas Exploration

by Lynn Moser[1]
Robert G. Piotrowski[2]

Amoco Production Company and UGI Development Corporation of Valley Forge, PA, whose gas-utility division serves customers in eastern Pennsylvania, began an extensive exploratory drilling program in Pennsylvania in May of 1977. Nine exploratory wells were drilled in 1977; four were producers and five were dry holes (Oil and Gas Journal, February 20, 1978). The four producers indicated good potential in Pennsylvania and the program was continued into 1978.

Nine wells were drilled in 1978; four were completed as producers, two were completed as dry holes, and three are currently drilling. Due to the continued success of the project, three additional wells have been located in Somerset County with drilling planned for 1979.

In the Amoco-UGI program to date, out of a total of 18 wells drilled, eight are successful, seven are dry holes, and three are being drilled. The eight producing wells have flow rates ranging between 14 mcfd and an estimated 37,000 mcfd.

The Oriskany (Lower Devonian) Formation has been the most successful target with six wells producing from this horizon. One well in the program produces from the Tuscarora (Silurian) and one from the Upper Devonian.

The program has been concentrated in four counties. Two wells in the program are located in Centre County, Fayette County has two wells, Somerset County has a total of sixteen wells or locations, and Westmoreland has had one well drilled.

1978 Completions

Three wells were begun in 1977 but not officially completed until 1978. These include the B-1 Berwind Corp., the #2 Texasgulf, and the #1 Donald McCann.

The B-1 Berwind Corp. well is located about 6½ miles southwest of the town of Windber, Windber quadrangle, Shade Township, Somerset County. Drilling began on December 4, 1977, and was completed December 8, 1977, as a dry hole reaching a total depth of 1,112 feet. The well was permitted to the Oriskany Formation at a depth of 8,700 feet but plugged on December 23, 1977, due to revised seismic data received by the operator.

---

[1] Student Intern, Pennsylvania Geological Survey, Thiel College, Greenville, PA.

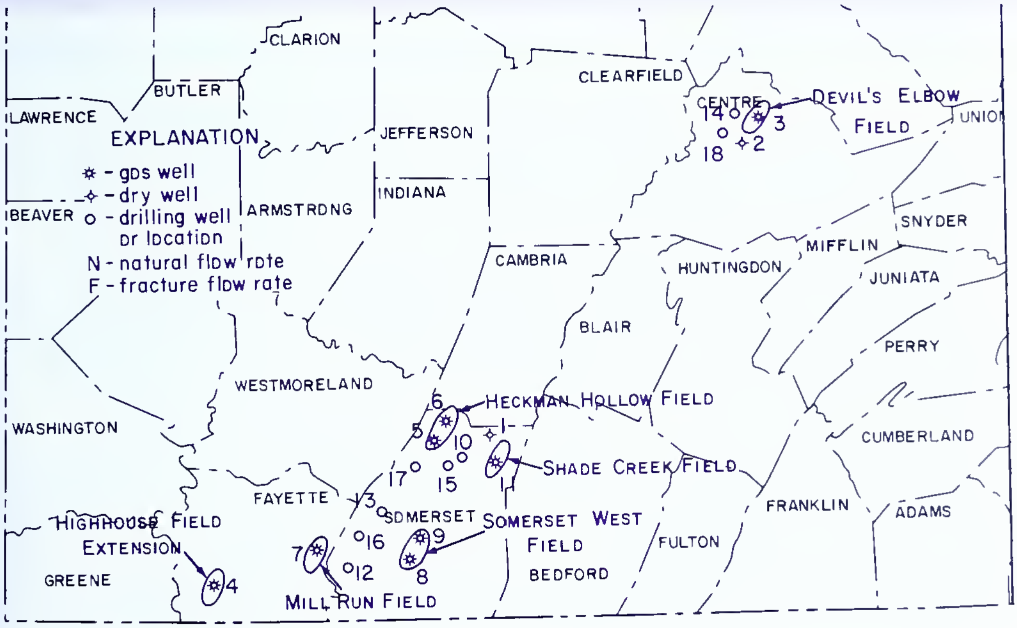
[2] Chief, Oil & Gas Geology Division, Pennsylvania Geological Survey, Pittsburgh, PA.

Drilling began on a development well, the #2 Texasgulf, in the Devil's Elbow field on June 8, 1978, and was completed July 7, 1978. The well was completed as a dry hole at a total depth of 13,059 feet in the Tuscarora (Silurian) Formation. The #2 Texasgulf is located about ½ mile southwest of the #1 Texasgulf, Snow Shoe southeast quadrangle, Boggs Township, Centre County. The apparent discovery well, the #1 Texasgulf, has an estimated natural flow rate of 37,000 mcfd but has not been officially completed. The well remains a tight hole to date.

-1 Berwind
TD - 1112′
D&A
#2 Texasgulf
TD-13,059′ Tuscarora
D&A
#1 Texasgulf
TD-11,187′ Tuscarora
P-37,000 Mcfd - N
#1 McCann
TD-3,600′ Upper Devonian
P-14 Mcfd - F
#1 Spory
TD-8,950′ Oriskany
P-250 Mcfd - F
#1 Yoder
TD-9,067′ Oriskany
P-1,380 Mcfd - F

(7) #1 Maude Mountain
TD-8,150′ Oriskany
IP-500 Mcfd - F
(8) #1 Hemminger
TD-8,902′ Oriskany
IP-2,600 Mcfd - F
(9) #1 Engleka
TD-9,198′ Oriskany
IP-4,100 Mcfd - F
(10) #1 Naugle
Proposed Depth - 9,100′
(11) #1 Ott
TD-9,000′ Oriskany
IP-1,430 Mcfd - F
(12) Commonwealth of PA #111-A
Proposed Depth - 9,000′

(13) #1 Barron
Unofficial TD-8,852′
Oriskany
(14) #1 C & K Coal
Proposed Depth - 11,500′
Amoco-Phillips Well
(15) Edward A. Kirk
Proposed Depth - 8,600′
(16) Commonwealth of PA
Proposed Depth - 3,150′
(17) #1 Stemmler
Proposed Depth - 3,600′
(18) #1 C & K Coal Co/Gas Uni
Proposed Depth - 11,500′
Amoco-Phillips Well



The #1 Donald R. McCann is located about 3½ miles northwest of the town of Smithfield, Smithfield quadrangle, Nickolson Township, Fayette County. The successful Upper Devonian well is an extension of the Highhouse field, producing gas at 14 mcfd from 3,462 feet after fracturing. The total depth of the #1 McCann is 3,600 feet.

Other wells which were located and completed in 1978 include the #1 Spory, the #1 Maude Mountain, and the #1 Hemminger.

The #1 Spory is located about 8 miles northwest of the town of Boswell, Boswell quadrangle, Conemaugh Township, Somerset County. It is a development well in the Heckman Hollow field which was discovered in 1977 by the #1 David Yoder well, also part of the Amoco-UGI program. After fracturing, the Spory is producing at a rate of 250 mcfd from a horizon located in the Oriskany (Lower Devonian) Formation between 8,840 feet and 8,866 feet. Drilling began on August 19, 1978, and was completed on September 27, 1978, at a total depth of 8,950 feet.

The #1 Maude Mountain, located 5 miles north of the Ohiopyle field and 10 miles southeast of the town of Connellsville, Mill Run quadrangle, Springfield Township, Fayette County, is the discovery well of the Mill Run field. After fracturing, a flow rate of 500 mcfd was recorded from the Oriskany Formation at a depth of 7,946 feet. Drilling began on May 24, 1978, and was completed August 17, 1978, at a total depth of 8,150 feet.

The #1 Hemminger, located a few miles southwest of Somerset, Murdock quadrangle, Somerset Township, Somerset County, is a successful development well in the Somerset West field, discovered in 1977 by the #1 Engleka. Drilling of the Hemminger well commenced on July 15, 1978, and was completed September 6, 1978, at a total depth of 8,902 feet. After fracturing, a flow rate of 2,600 mcfd was recorded from the Oriskany Formation at a depth between 8,726 feet and 8,820 feet.

Three wells are currently being drilled and are expected to be completed in 1979. These are the #1 Naugle Gas Unit, the Commonwealth of PA #111-A, and the #1 Dale S. Barron, all located in Somerset County.

The #1 Naugle Gas Unit is about 4½ miles southwest of the town of Windber, Hooversville quadrangle, Shade Township, Somerset County. The #1 Naugle is a development well in the Shade Creek field which was discovered in 1977 by the #1 Ott well, also part of the Amoco-UGI program. Drilling of the Naugle began on October 28, 1978. On January 12, 1979, the well had reached 9,090 feet with a scheduled total depth of 9,100 feet in the Oriskany Formation.

Drilling began on October 6, 1978, at the Commonwealth of PA #111-A and had reached a depth of 8,278 feet by December 22, 1978. The expected total depth is 9,000 feet in the Oriskany Formation. The well is about 8 miles northeast of Ohiopyle, Kingwood quadrangle, Lower Turkeyfoot Township, Somerset County.

Drilling of the #1 Dale S. Barron well began on December 2, 1978. It is located about 5 miles west of Somerset and about 4 miles northwest of the Somerset West field, Bakersville quadrangle, Jefferson Township, Somerset County. This new field wildcat has been unofficially completed as a producer with an estimated natural flow rate of 3,000 mcfd at a total depth of 8,852 feet in the Oriskany Formation.

Three additional locations have been selected in the Amoco-UGI program for 1979. These proposed wells are the #1 Edward A. Kirk, the #1 Commonwealth of PA, and the #1 Stemmler, all located in Somerset County.

The #1 Edward A. Kirk location is in the Stoystown quadrangle, Stoneycreek Township, Somerset County. The scheduled target is the Oriskany Formation at a total depth of 8,600 feet.

The Upper Devonian is the scheduled target formation for two locations, the #1 Commonwealth of Pennsylvania and the #1 Stemmler.

The #1 Commonwealth well location is about 2 miles directly west of Laurel Hill State Park, Kingwood quadrangle, Middlecreek Township, Somerset County. The scheduled total depth is 3,150 feet.

The #1 Stemmler well location is about 3 miles northeast of Jennerstown, Boswell quadrangle, Jenner Township, Somerset County, and is scheduled for a total depth of 3,600 feet.

Two other wells, #1 C & K Coal and the #1 C & K Coal/Gas Unit, are significant deep tests (see Figure 1) but are not part of the Amoco-UGI drilling program. Both wells are farmouts to Amoco Production Co. from Phillips Petroleum Co. Drilling of the #1 C & K Coal well began on April 20, 1978, and at the time of writing was reported at a depth of 11,170 feet with an expected total depth of 11,500 feet in the Tuscarora (Silurian) Formation. The well is located about 1½ miles northwest of the #1 Texasgulf well in Snow Shoe southeast quadrangle, Boggs Township, Centre County. The #1 C & K Coal/Gas Unit location is about 1 mile southwest of the #1 C & K Coal well. The scheduled depth of this well is 11,500 feet which is also in the Tuscarora Formation.

Summary

In the Amoco-UGI program, 18 wells have been drilled, eight successful, seven dry holes, and three drilling wells. The eight successful wells have reported flow rates between 14 mcfd and 37,000 mcfd. Location for three additional wells have been named for 1979.

By far the most successful well of the entire program is the #1 Texasgulf, located in Centre County. The well is producing from the Tuscarora (Silurian) Formation at an estimated natural rate of 37,000 mcfd.

The success of the Amoco-UGI exploratory program, both in 1977 and 1978, indicates excellent natural gas potential in Pennsylvania and exploratory activity in the state is expected to continue.

Rare Fossil Fish Surfaces At The William Penn Memorial Museum

by Donald Baird[1]

Of all the rare fishes living today perhaps the most notorious is the coelacanth, (pronounced SEE-la-canth) *Latimeria chalumnae*. People who wouldn't know a hake from a hagfish have heard of the five-foot, steel-blue monster that was hauled from the ocean off East Africa in 1938 and proved to be the living representative of a race that scientists had thought to be extinct since the reign of *Tyrannosaurus rex.* Discovery of a living coelacanth of course sparked renewed interest in its fossil relatives, particularly as the coelacanths were an offshoot from the line of Devonian lobefin fishes that evolved into amphibians and thus became, ultimately, our own ancestors. *Latimeria* is thus our closest living relative in the fish kingdom.

As additional specimens of *Latimeria* were caught scientists were able to analyze its anatomy in detail. The new information they gained was of course invaluable in interpreting the anatomy and way of life of the ancient coelacanths, of which only the hard parts—skeletons, scales, and in some cases the calcified swim-bladder—had been perserved as fossils.

Students of fossil coelacanths necessarily zeroed-in on Pennsylvania, for one of the best-known members of the group, *Diplurus*

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Princeton University
Princeton, NJ 08540

newarki, had first been described on the basis of skeletons found in the gray Triassic argillite near North Wales in Montgomery County; additional specimens have been collected near Gwynedd and elsewhere in the state. The greatest number of *Diplurus* fossils come from New Jersey, particularly from the Granton Quarry in North Bergen and the excavation for Firestone Library on the Princeton University campus, where concentrations as high as 12 coelacanths per square foot occurred. When restudied by Dr. Bobb Schaeffer of the American Museum of Natural History (figure 1), *Diplurus* proved to be remarkably similar in basic structure to its living relative, though of course distinctive in detail, as might be expected in fishes separated by 190 million years of time.

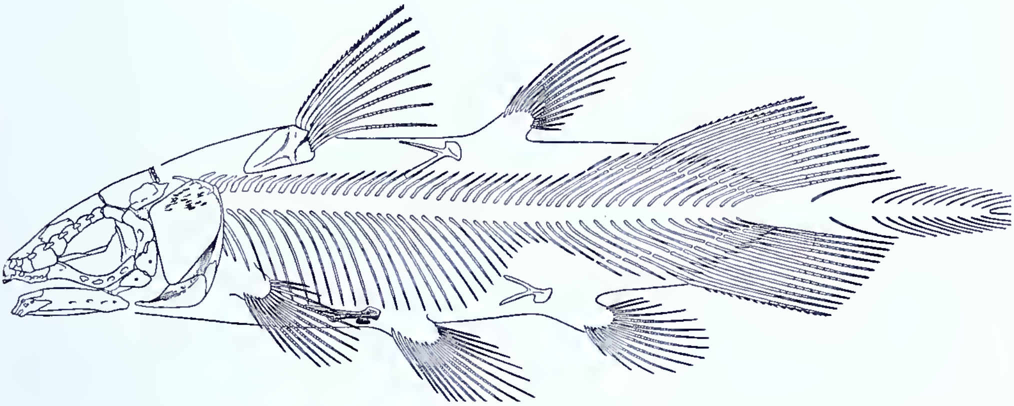

Figure 1. Skeleton of *Diplurus newarki* as reconstructed by Dr. Bobb Schaeffer.

One significant difference is that, although today's living *Latimeria* is a deep-water marine fish, *Diplurus* was an inhabitant of fresh-water lakes. It was by far the most abundant inhabitant of ancient Lake Lockatong, which once extended from southeastern Pennsylvania to what is now the Hudson River. A survey of their history shows that fresh water was the original home of the coelacanths and their preferred habitat until Jurassic time, when some members of the group succeeded in establishing themselves in marine waters—where the last survivor is found today.

Although coelacanth fishes are known from as far back in time as the Devonian period, our Triassic friend *Diplurus* was until recently the only one found in Pennsylvania. Considering the extensive deposits of Paleozoic fresh-water sediments in the state, it seemed inevitable that a pre-Triassic coelacanth would eventually be found here. And sure enough, one has come to light: not on an outcrop but in a museum drawer at the William Penn Memorial Museum, where it had lain unrecognized for a hundred years.

The specimen illustrated here (figure 2), the first Pennsylvanian coelacanth from Pennsylvania, was collected about 1877 by the Hon. I. F. Mansfield at his coal mine near Cannelton in Beaver County. There is hardly space here to do justice to the contributions made by this remarkable man, who was so dedicated a fossil-collector that I sometimes wonder if he didn't regard the coal as just a byproduct of his mine. Well, probably not—a 12-foot seam of beautiful cannel is nothing to sneeze at—but the shale immediately underlying the cannel proved to be a treasurehouse of plant and animal fossils which Mansfield devoted himself to saving for science. The splendid collections now housed at the Smithsonian, Harvard, Princeton, and the William Penn Memorial Museum (among other institutions) bear lasting witness to his zeal.

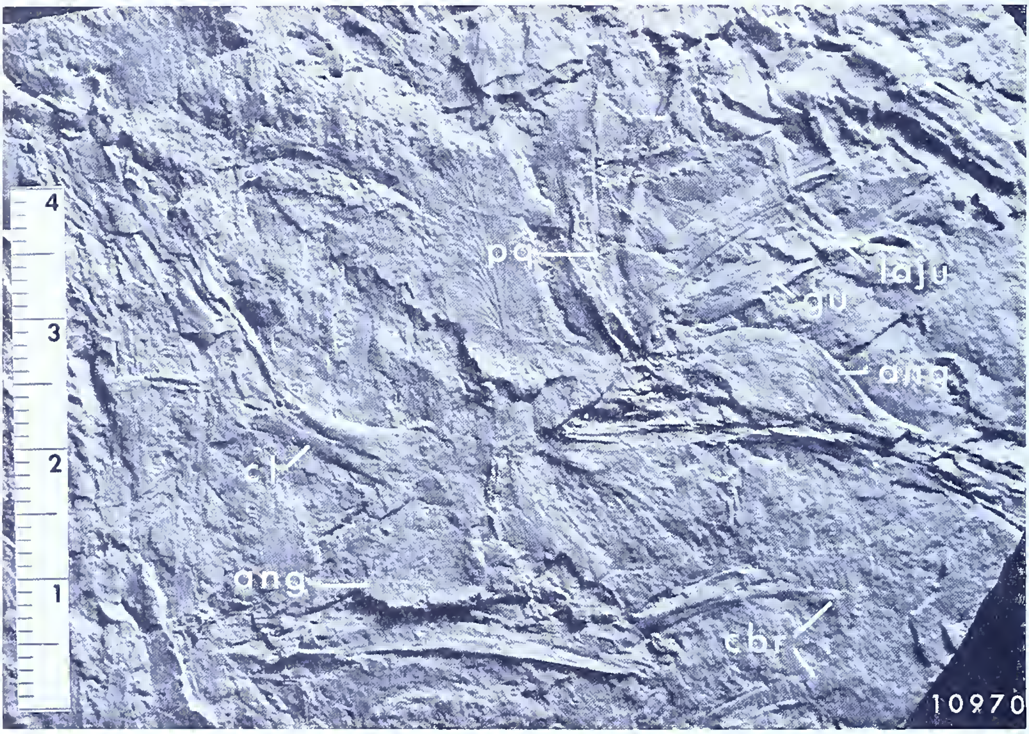

Figure 2. Disarticulated bones of the Cannelton coelacanth include the upper jaw (pq) and lower jaws (ang), a chin plate (gu), two gill-arches (cbr), cheek bone (laju), and a shoulder blade (cl). Scale is 4 centimeters long. William Penn Memorial Museum No. 10970.

Subsequent studies by geologist Frank W. DeWold (1929) showed that the Cannelton deposits had been laid down in an oxbow-shaped channel during the Upper Kittanning coal-forming cycle in mid-

Pennsylvanian time, about 300 million years ago. Most of the fossils preserved are seed-ferns and other representatives of the coal-swamp flora that is so familiar to Pennsylvania fossil-hunters. But there are also abundant eurypterids (commonly called "sea-scorpions" but in this case strictly fresh-water), cockroaches and other insects, salamander-sized and snake-like amphibians, and a variety of fishes.

You can hardly blame Mansfield or the State Survey paleontologists of the last century for not recognizing the coelacanth specimen, for it doesn't look like a fish at all, not even one the cat dragged in. As just another nondescript fossil it disappeared into dead storage with the rest of the Second Survey collection. Only in recent years, when the William Penn Memorial Museum assumed responsibility for the old Pennsylvania Survey collections, was curator Donald Hoff able to unpack them and make them accessible for study. No doubt it was serendipity that led me, while visiting Harrisburg to study Triassic amphibians and reptiles, to discover this unexpected and long-concealed treasure.

Although the bones of the coelacanth's head and shoulder girdle have come apart and are strewn about on the slab, each of them has a highly characteristic shape that is instantly recognizable to anyone who has worked with fishes of this type. As it happens, I had collected a good many specimens of the same species at a famous fossil locality in Ohio: the Linton mine dump near the mouth of Yellow Creek on the Ohio River near East Liverpool. These Linton coelacanths, *Rhabdoderma elegans* (Newberry), lived about a million years later than the one from Cannelton and were probably its descendants.

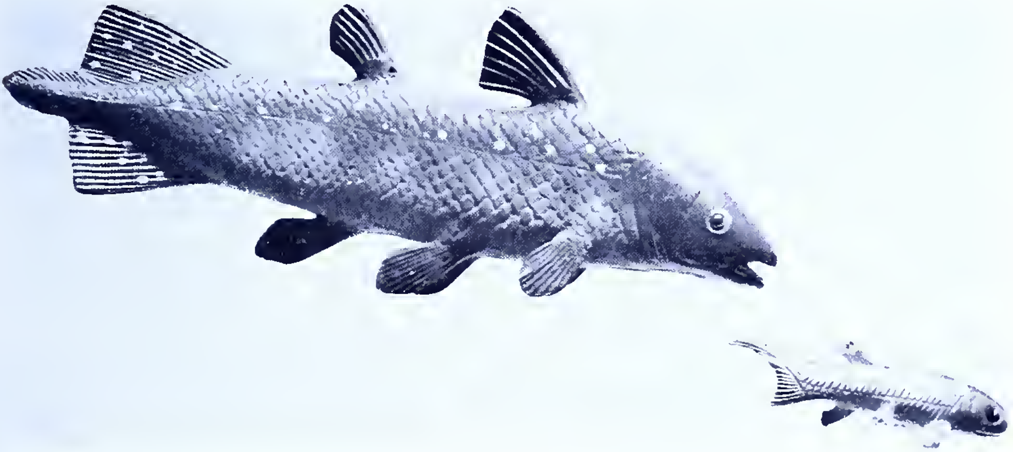

Figure 3. *Rhabdoderma* about to pounce on *Haplolepis,* as modeled by the Rush Studio for the William Penn Memorial Museum.

Rhabdoderma elegans was not a large fish—about six inches was its usual adult length –but it had a voracious appetite out of proportion to its size. The evidence for this can be seen in a specimen from Linton (PU 19299 in the Princeton collection) that was fossilized with a smaller fish in its gullet. The victim in this case was the palaeoniscoid *Haplolepis tuberculata,* a diminutive and distant relative of today's diamond-scaled garpikes. It appears that the coelacanth had gulped its prey head-first and had swallowed all but the tail when something went wrong: either the palaeoniscoid was more than it could manage or, more likely, the coelacanth was itself snapped up by some larger predator while straining to engulf its victim. The *corpus delicti* of this little coal-swamp tragedy provides scientists with their first evidence of what *Rhabdoderma* ate—or at least what it *thought* it could eat (figure 3).

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A Quarry Invitation

William O. Faylor, Jr., President of Faylor-Middlecreek, Inc., operator of the Winfield Quarry, has sent this generous message to all their mineral club friends:

Faylor-Middlecreek, Inc., will continue open house visitations at the Winfield Quarry on May 19th and September 22nd, 1979. To comply with governmental regulations and to insure the safety of all visitors to the quarry, all participants must adhere to the established rules provided by the company.

There is a steep climb into and out of the quarry and anyone not physically able to climb the steep hills coming out of the quarry on their own should not walk down. Visiting vehicles are not permitted at anytime into the quarry. Hard hats, safety shoes, and safety glasses are required. A $1.00 donation from each visitor will defray the costs of safety personnel on duty.

The quarry has some attractive and interesting specimens not found in many other quarries. The Open House will run from 8:00 a.m. to 4:00 p.m.; there will be a food stand in the parking lot. Those planning to attend should advise the company in advance. Faylor-Middlecreek Inc., Winfield, PA 17889.

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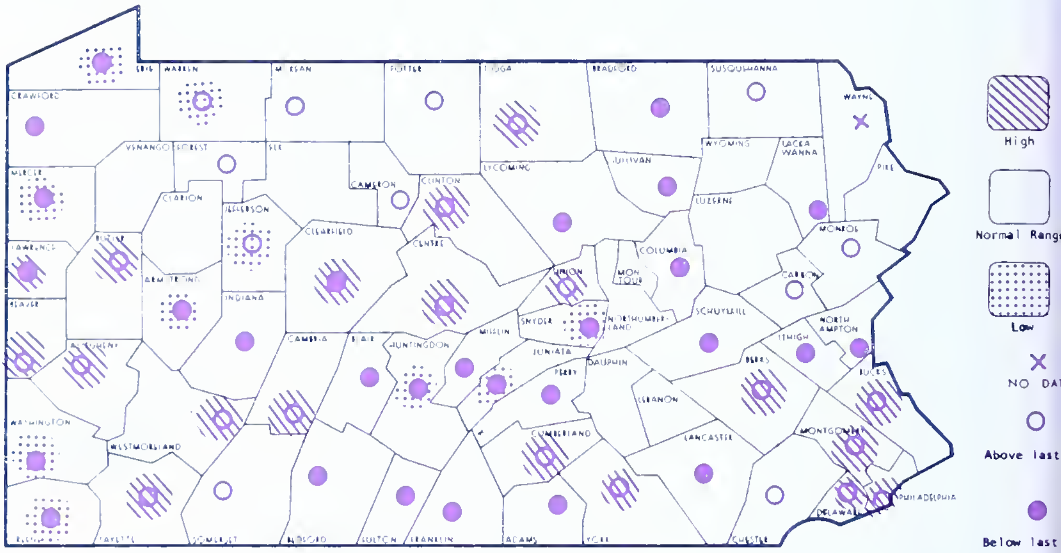

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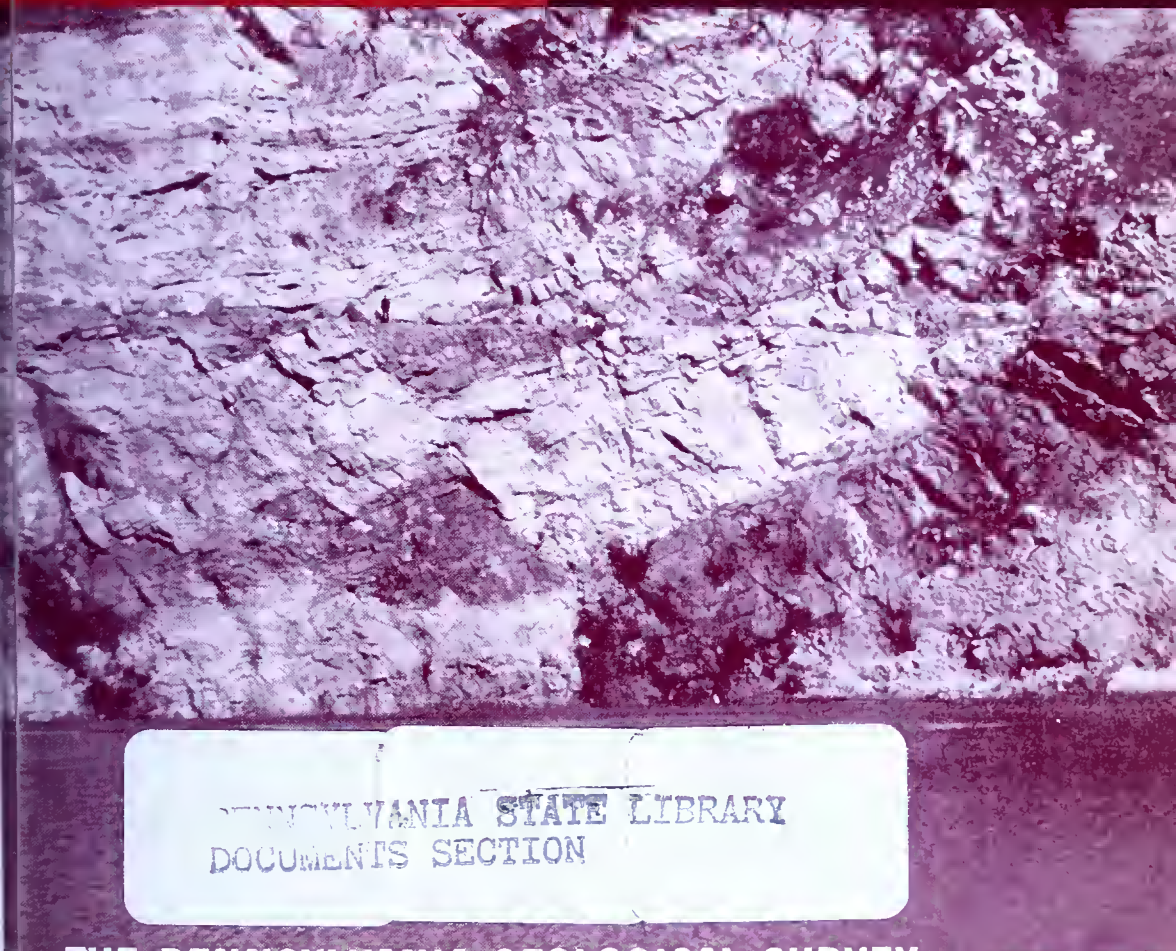

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TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Normal faults exposed in limestone quarry of York Stone and Supply Company at York, Pennsylvania. For scale, note figure on "bench" in center of photo. Photo courtesy of Pennsylvania Historical and Museum Commisson.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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JUNE 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

A NEW CHALLENGE

As reported in this issue, the Bureau of Topographic and Geologic Survey has taken on a regulatory function, now that the Division of Oil and Gas Regulations has been transferred to our Bureau. We already have a pleasant and constructive working relationship with the oil and gas exploration industry, by virtue of the data and services provided by our long established Division of Oil and Gas Geology. It is our hope and intention to develop a constructive working relationship with the oil and gas drilling industry as we take on the legislatively mandated functions of assuring physically and environmentally proper oil and gas drilling and plugging practices. Of course, it won't always be easy; we recognize that a complex industry will have complex problems. And we recognize that there is a responsibility to protect the interests of all Pennsylvanians. We are also very much aware that as a major energy consuming state, we can use all the new oil and gas that can possibly be developed within our borders.

The Bureau of Topographic and Geologic Survey accepts the new challenge, with all of its ramifications. It is our hope that if all parties involved are reasonable, the results will also be fair and reasonable. After many decades of geological services to the Commonwealth, our Survey has a well established, professional reputation. We are well accepted as the "guys with the white hats," and even with our new range of responsibilities, we do not plan to change our hats.

Arthur A. Socolow

LANDSLIDE ENCOUNTERS

by John P. Wilshusen

Landslides occur in Pennsylvania and are widespread in the spring when the ground thaws, saturating soil and rock. At that time rocks fall from road cuts and soil slumps on hillsides. Debris slides of rock, soil and vegetation are also common, especially during periods of heavy rainfall. All three types of landslides may involve homes, industry, roads and farmlands. Each rockfall, slump and debris slide, (Figures 1-3) is representative of commonly observed landslides in Pennsylvania. In addition to these, however, large complex slope failures (Figure 4) occur in western Pennsylvania. These occurrences involve slump, debris slide, flow, rotation and lateral translation of the moving material from the beginning to the end of the movement.

Rockfall is the free fall from a rock face, or bounding down a steep slope, of rock fragments loosened by frost and ice wedging, flowing water, or tree root wedging. It occurs wherever there is a steep rock face present, both man-made and natural.

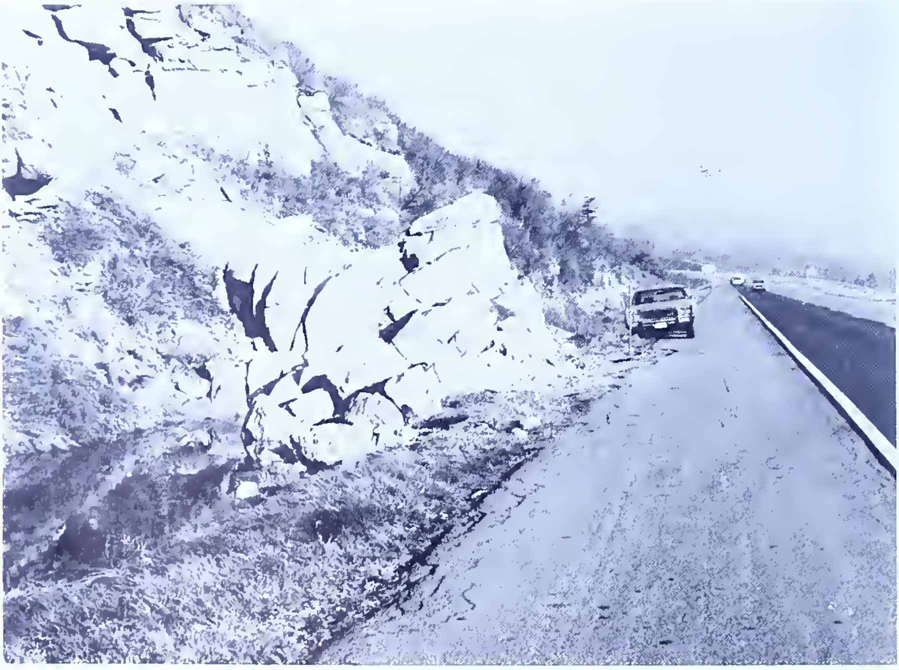


Figure 1. Rockfall from a road cut in central Pennsylvania.

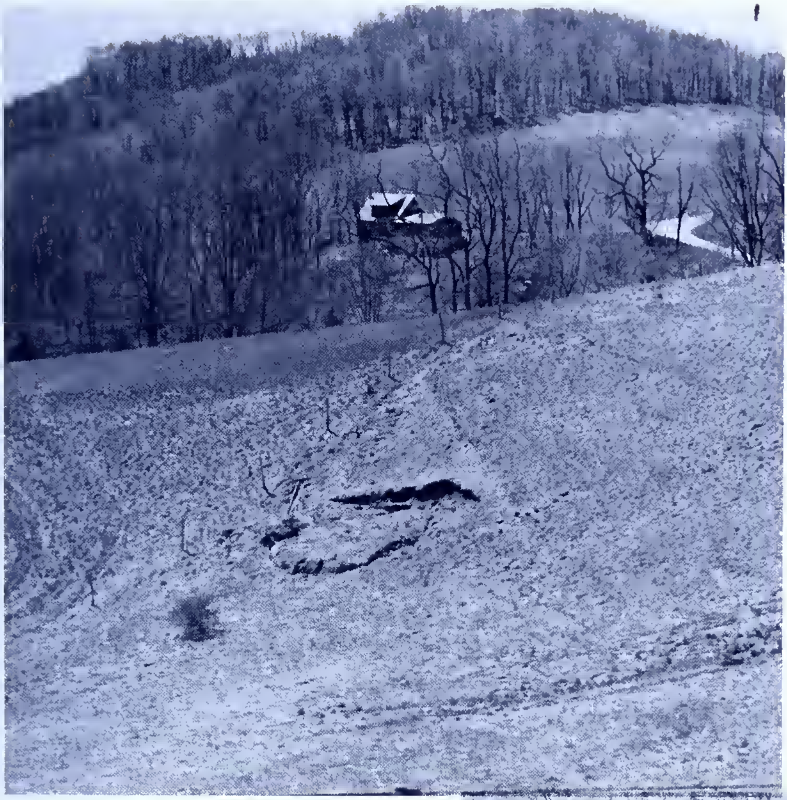


Figure 2. Soil slump from a hillside in a farm field.

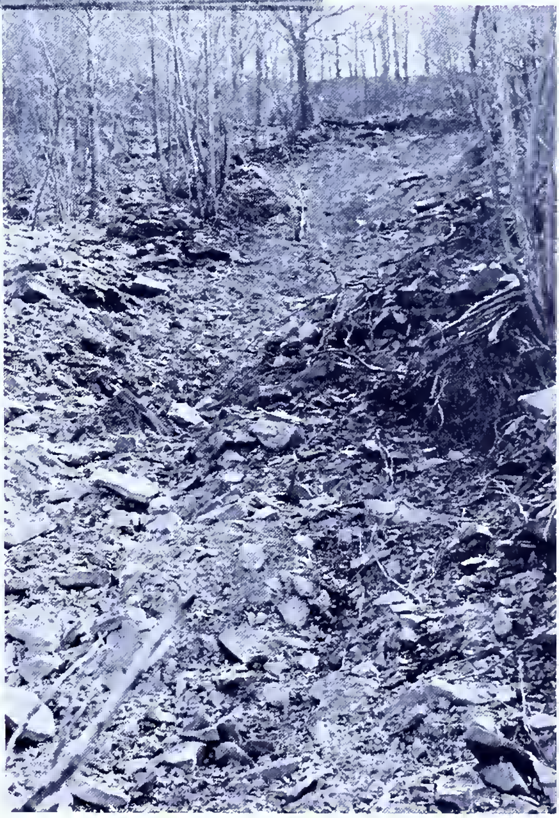


Figure 3. Debris slide on a forested mountain slope.

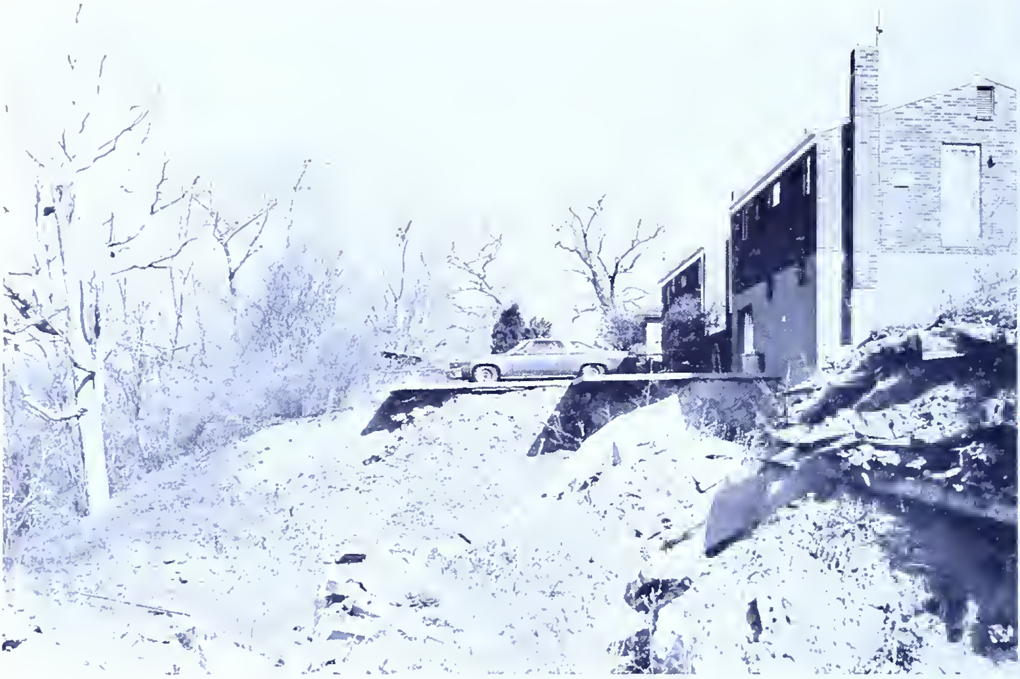


Figure 4. Upper portion of a large complex slope failure in western Pennsylvania.

Slump frequently takes place in soil and weathered rock above the bedrock surface. It is caused by excessive water in the soil and results in slope failure. A depression opens at the head of the slump and a mound of hummocky soil forms at the toe. Slump is associated with very wet, particulate soil and weathered rock and may occur on a gentle slope as well as a steeper one. Undercutting at the base of the slope, either natural (a stream) or man-made (a road cut), accelerates slumping.

Debris sliding is the downslope movement of soil, rock and trees along a planar surface. It is associated with steep, unstable slopes and is often expressed as a stripped out pathway down a mountainside. Movement starts near the top with the mass of sliding material knocking out everything in its path until it comes to rest as a jumbled, chaotic heap.

The complex slope failures that occur in western Pennsylvania are directly related to rock structure, composition, and topography. The dip of the bedrock layers is almost flat, with successive stratigraphic units composed of sandstone, siltstone, shale, coal, clay and limestone. Collectively, these rocks form a broad plateau characterized by narrow, steep-sided valleys and broad, flat ridge crests. Most of the bedrock units are broken by joints and bedding plane openings

Oil And Gas Regulatory Division To Pennsylvania Survey

The Division of Oil and Gas Regulation, formerly with the Bureau of Land Protection, has been transferred to the Bureau of Topographic and Geologic Survey. This is one of a number of recent reorganizational moves within the Department of Environmental Resources, designed to bring together related functions for more effective service.

The Division of Oil and Gas Regulation is based in the Kossman Building, 100 Forbes Avenue, Pittsburgh 15222, as is the Division of Oil and Gas Geology, a long-standing member of the Bureau of Topographic and Geologic Survey. These two Divisions will continue their separate identities and functions, but will maintain close coordination.

The Division permits, regulates and inspects wells drilled for oil and natural gas, wells used for underground storage of natural gas and wells to be plugged and abandoned. This Division will also be responsible for implementing the State's responsibilities to the new Natural Gas Pricing Act recently passed by Congress.

In taking on the Division of Oil and Gas Regulation, the Survey enters into a major new role of regulation and inspection. Our intent is to address this responsibility with the same professional standards and integrities that have stood us well over the years.

Landslides continued

which allow ground water to move freely through the rock mass. There are, however, some relatively impervious clay units which interrupt ground water circulation resulting in a build up of pore water pressure. This creates an instability which may lead to slope failure.

The complex landslides come in all sizes, ranging from small movements in a yard or along a highway to massive failures involving entire hillsides and communities. Though western Pennsylvania is noted for this type of landslide, it does not appear to have the largest in the state; that honor may belong instead to a prehistoric landslide in which a massive slice of mountain separated from the main mountain northwest of Nanticoke in Luzerne County.

In addition to the types of landslides discussed here, there are others: debris avalanche, rockslide, earthflow and mudflow. Those described above, however, are the most frequently encountered in Pennsylvania.

History Of Streamflow Records For The Susquehanna River At Harrisburg, Pa.

by Carney P. Humphreys
Water Resources Division
U.S. Geological Survey

The rich history of the Harrisburg area has from its very beginning been closely associated with the Susquehanna River which flows by the city's doorstep. Data from the river have been used for many purposes, but, by far, the most important use has been in the development and management of this valuable natural resource.

The first official record of river levels began in 1874. Mr. William Kelker read gage heights from a vertical, painted, staff gage on a pier of the old Market Street bridge from 1874 to 1893.

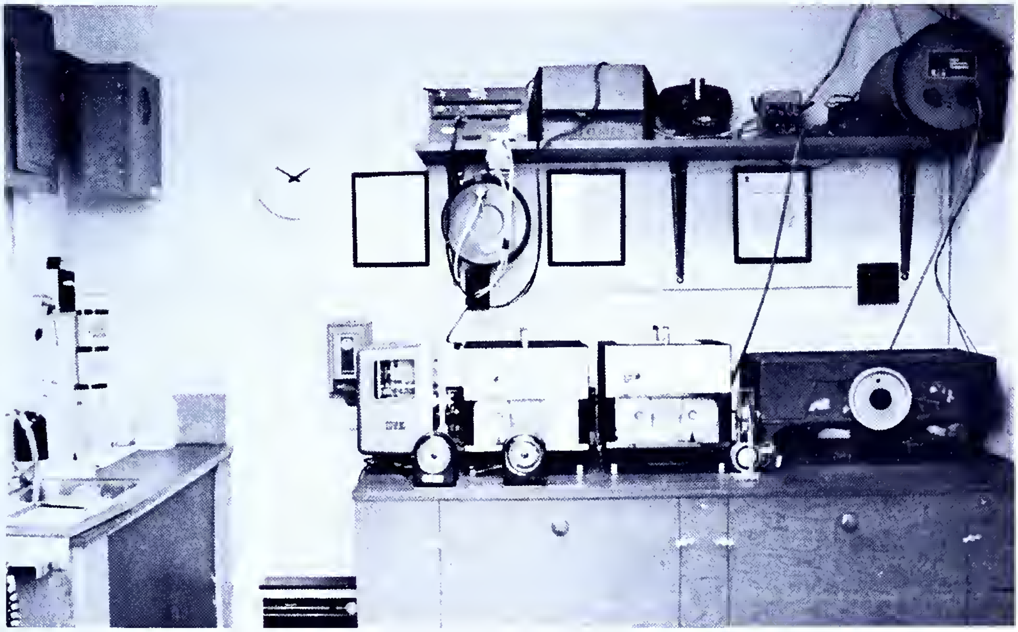
The systematic collection of daily observations of river gage heights began with the establishment of a staff gage in the pump well of the old Harrisburg Water Works at the foot of North Street in October 1890. Mr. E. Mather, President of the Harrisburg Water Board, made readings at this site from October 1, 1890 to July 18, 1904. An interesting note here is that the "zero" or lower end of the gage was set at the "low water mark" of 1803 or 289.4 feet above mean sea level. This later enabled hydraulic engineers of the U.S. Geological Survey to utilize this gage-height record to compute daily river discharge for the period. The first measurement of streamflow discharge was made March 31, 1897 by Mr. Paul of the Water Supply Commission of Pennsylvania.

On July 18, 1904, the U.S. Geological Survey installed a standard "chain type" river gage on the upstream side of the present Walnut Street Bridge which is 2100 feet downstream from the old Water Works Pumping Station at North Street. Records were kept at this site until September 30, 1928.

In 1928, a reinforced concrete gage house and well were constructed on the east bank of the river at Nagle and Front Streets in Shipoke to house an automatic, continuous, gage-height recorder. This gaging station was financed by the Philadelphia Electric Power Company and operated by the U.S. Geological Survey under a Federal Power Commission license. Official streamflow records were collected at the Nagle Street gage until August 31, 1975.

The record-breaking flood of June 1972, caused by Tropical Storm Agnes, produced a flood level 0.2 feet above the roof of the

Susquehanna River monitoring and gaging station at Harrisburg: Historic flood marks are marked along right edge of scale on building; flood stages recorded for 1975, 1972, 1936, 1894, 1889, and 1784.



Instruments in Susquehanna River monitoring station at Harrisburg; includes automated LANDSAT satellite data collection system, electrical tapes, and recorders.

Nagle Street gage. Because of the need to measure floods and to have flood-warning devices in continuous operation, the gage had to be relocated. The new gage was established on City Island near the eastern edge of the island and 60 feet downstream from the Market Street Bridge. This station is operated by the U.S. Geological Survey under cooperative programs with the Pennsylvania Department of Environmental Resources, the National Weather Service and the Philadelphia Electric Company. Records began at this gage on September 1, 1975 and continue to date.

The latest type of instrument to be operated in the City Island gage is a Convertible Data Collection Platform which transmits river stages once every three hours to a Geostationary Operational Environmental Satellite (GOES) some 22,300 miles above the equator. The GOES immediately relays the data back to an earth receive site at Wallops Island, Virginia where it is relayed via dedicated landlines to various data users including the U.S. Geological Survey, National Weather Service River Forecast Center, and the U.S. Army Corps of Engineers. About 8 seconds time is required for the data to make its round trip journey to the satellite.

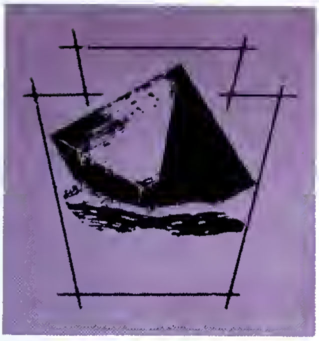
The National Weather Service has utilized the several gages in the Harrisburg area to monitor river levels and to forecast floods; but, their periods of observed record at each of the gages differ from those of the U.S. Geological Survey.

Water-quality records are also available for the Susquehanna River at Harrisburg. The U.S. Geological Survey has published partial records of water quality from October 1944 to January 1953 and from March 1956 to present. Daily records of specific conductance, pH, water temperature, and dissolved oxygen have been collected and published since May 1974. Daily suspended sediment discharge records are available from October 1963 to September 1968 and from April 1970 to the present.

In addition to the station at Harrisburg, the Pennsylvania District of the U.S. Geological Survey maintains 265 continuous streamflow gaging stations, 195 partial-record gaging stations (crest-stage and low-flow), 55 chemical and sediment stations, and 67 observation wells. Hydrologic data for these sites are published annually in "Water Resources Data for Pennsylvania." The publication is in three volumes:

Volume 1. Delaware River Basin
Volume 2. Susquehanna and Potomac River Basins
Volume 3. Ohio River and St. Lawrence River Basins

For information on water resources data in Pennsylvania contact the U.S. Geological Survey, Water Resources Division, P.O. Box 1107, Harrisburg, Pennsylvania 17108.



EARTH SCIENCE TEACHERS' CORNER

EARTH AND SPACE SCIENCE IN PENNSYLVANIA: A TWENTY YEAR PERSPECTIVE

by William H. Bolles, Science Education Adviser,
Department of Education

The revival of the Earth Sciences in Pennsylvania began early in 1958 when the then Department of Public Instruction prepared the first outline for a course to be called Earth and Space Science. The work began under the direction of Dr. Charles Boehm, Superintendent of Public Instruction, and grew out of his attendance at an Air Force Convention held in Dallas, Texas. In his words, "This experience led to the realization that the Space Age in which we now live, and about which we know so little, will be commonplace to our students. Therefore, the inclusion of Earth and Space Science in the program of Pennsylvania's public schools has become an imperative issue."

In 1959 the first Earth and Space Science Teaching Guide was published and in 1961 a comparable guide was developed for elementary school teachers. The secondary guide was revised in 1963 and an entirely new guide published in 1973.

The introduction of the earth sciences in Pennsylvania coincided with the decision of the American Geological Institute to develop up to date resource materials for secondary school teachers. In the summer of 1959 a conference was held at the University of Minnesota, known as the Duluth Conference, which resulted in the publication of a Geology and Earth Science Sourcebook by Holt, Reinhart and Winston in 1962.

The National Science Foundation awarded a grant in 1963 which continued these efforts to improve earth science education and the project became the Earth Science Curriculum Project (ESCP) with headquarters at Boulder, Colorado. Dr. Robert Heller was the first director. The resulting course, Investigating The Earth, was pilot tested at two centers in Pennsylvania. The Harrisburg center was directed by Alan Geyer of the Pennsylvania Geologic Survey while

EARTH AND SPACE SCIENCE ENROLLMENT DATA

Years	Total Enroll-ment	% Change	ESCP Enroll-ment	ESCP %	Total Secondary Enrollment	% Change	% Earth Science of Total Enrollment
1958-59	*4,500				736,269		0.6
1959-60	*25,000	+ 455.6			797,711	+ 8.3	3.1
1960-61	36,696	+ 46.8			818,246	+ 2.6	4.5
1961-62	68,431	+ 86.5			853,311	+ 4.3	8.
1962-63	65,280	- 4.6			899,518	+ 5.4	7.3
1963-64	73,288	+ 12,3			944,491	+ 5.0	10.2
1964-65	114,780	+ 56.6			966,808	+ 2.4	11.9
1965-66	132,149	+ 15.1			970,358	+ 0.4	13.6
1966-67	102,855	- 22.2			988,248	+ 1.8	10.4
1967-78	108,247	+ 5.2	8,074	8	1,019,787	+ 3.2	10.6
1968-69	112,439	+ 3.9	36,638	33	1,049,724	+ 3.1	10.7
1969-70	118,754	+ 5.6	45,891	39	1,078,943	+ 1.5	11.0
1970-71	131,005	+ 10.3	45,538	35	1,099,570	+ 1.8	11.9
**1971-72	137,074	+ 4.6	48,195	35	1,121,826	+ 2.7	12.2
1973-74	139,074	+ 1.5	50,472	36	1,137,660	+ 1.8	12.2
1975-76	124,718	- 10.3	40,550	33	1,116,696	- 0.7	11.2
1977-78	122,385	- 1.9	34,178	28	1,074,833	- 4.1	11.4

*Estimated enrollments.

**Data collected every other year from this date.

All data from Secondary Public School Report unless otherwise indicated.

the Lancaster center was under the direction of Jacob Freedman of Franklin and Marshall College.

Each center involved five schools during the 1964-65 school year. The materials were revised and tested again during the 1965-66 school year but the Harrisburg center was dropped in an effort to reduce costs.

The Investigating The Earth text was available for the 1967-68 school year, however, its late appearance resulted in its being adopted by only a relatively small number of schools. The ESCP enrollment that year was only 8% of the total number of students taking Earth and Space Science. The next school year the percentage rose to 33% and the following year to a high of 39%. In actual numbers of students enrolled in Investigating The Earth, the 1973-74 school year was the highest with 50,472 reported. Increasing enrollment brought the percentage this year to only 36%.

Although total enrollments are decreasing, the number of students in the Earth and Space Science curricula has been relatively stable since 1963-64.

The philosophy continues in Pennsylvania that this is a course for all students. At a time of increasing awareness of environmental concerns and a greater awareness of energy problems and needs there can be no better background upon which to build understanding of these issues than a study of the earth sciences. This interdisciplinary approach to the study of geology, astronomy, meteorology and oceanography is as much needed now as it was in the early days of the Space Age.

SURVEY ANNOUNCEMENTS

AVAILABLE MAPS AND CROSS SECTIONS OF DEVONIAN ORGANIC-RICH SHALES AND SANDSTONES OF WESTERN PENNSYLVANIA

The Bureau of Topographic and Geologic Survey, in cooperation with the Morgantown Energy Technology Center of the U.S. Department of Energy (under contract EY-76-S-05-5198), is in the process of completing a three-year study of the Middle and Upper Devonian organic-rich black shales in the subsurface of Pennsylvania. This study has involved regional and detailed geologic investigations of the organic-rich shales and their relationship to the total Middle and Upper Devonian clastic sequence in the northern and western part of the state. As a result of this study, nine stratigraphic cross sections and two maps at a scale of 1:250,000 have been published by METC/DOE. These items are available free of charge from the Pennsylvania Geological Survey. The nine cross sections show all of the Devonian strata from the top of the Onondaga Group to the base of the Mississippian (where it is not eroded). There are three sections oriented approximately north-south, and six oriented approximately east-west. The organic-rich black shales and the Upper Devonian sandstones are designated on these cross sections by distinctive patterns. The two 1:250,000 scale maps show: (1) Drilling Depth to the top of the Onondaga Group, and (2) Gas Shows and Production from the Middle and Upper Devonian Organic-rich Shales.

In addition to these items, a third 1:250,000 scale map, Structure Contours on top of the Onondaga Group, and 39 1:1,000,000 scale maps are available on open file. The 1:1,000,000 scale maps represent isopach, structure contour, and lithofacies maps of the organic-rich shale-bearing units and isopach and lithofacies maps of the Upper

Devonian sandstones. Open file items may be examined, or copied in blue line form for the price of reproduction.

This material is available at the offices listed below: Pennsylvania Geological Survey, 1201 Kossman Building, Pittsburgh, PA 15222; Morgantown Energy Technology Center, U.S. Department of Energy, Eastern Gas Shales Project, P.O. Box 880, Morgantown, WV 26505.

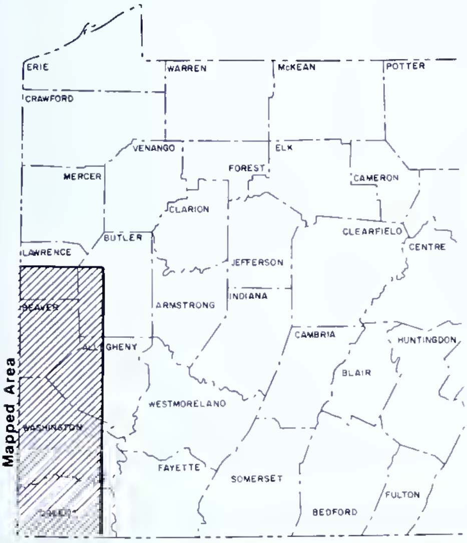
GEOLOGISTS JOIN SURVEY

Denise Royer, a native of Lancaster County, Pennsylvania, has joined the staff of the Environmental Geology Division of the Pennsylvania Survey and is primarily responsible for maintaining the water well inventory program. Denise received her Bachelor of Arts degree in geology from the University of Colorado in 1976 and, following graduation, worked as a ceramic research scientist. Her professional interests include hydrogeology and resource management.

Clifford H. Dodge, also a native of Lancaster County, has recently accepted a position as coal geologist with the Geologic Mapping Division of the Survey. His responsibilities include areal appraisals of the bituminous coal resources and geologic mapping in western Pennsylvania. Cliff received his B.A. in the geological sciences from Lehigh University in 1972 and his M.S. in the geological sciences from Northwestern University in 1976. Cliff comes to the Survey with over three years of experience with the Water Resources Division of the U.S. Geological Survey, where he spent much of his time conducting water resources investigations and geologic mapping in northwestern Pennsylvania. His professional interests include the geology of northwestern Pennsylvania (particularly the Mississippian stratigraphy), coal geology, ground-water hydrology, and water geochemistry.

SOUTHWESTERN PENNSYLVANIA LANDSLIDE MAPS ON OPEN FILE

Maps of landslides and related features in an area covering most of Greene, Washington, Beaver, Lawrence, Allegheny, and Butler counties, as shown on the index map below, have been released by the U.S. Geological Survey and are on open file at the office of the Pennsylvania Geological Survey. The maps consist of 55 quadrangles (7 1/2-minute series, 1:24,000 scale) which by different symbols show active or recently active landslides, old landslides, slopes that are susceptible to sliding, slopes with small landslides, areas susceptible to debris flows and debris avalanches, areas susceptible to rockfall, and areas least prone to landslides. The maps were prepared by W. E. Davies, J. S. Pomeroy, R. J. Hackman, and G. C. Ohlmacher of the U.S. Geological Survey.



The open file maps may be examined at the Pennsylvania Geological Survey, Executive House, 101 S. 2nd Street, Harrisburg, Pennsylvania 17101 and at the Pennsylvania Geological Survey, 1201 Kossman Building, 100 Forbes Avenue, Pittsburgh, Pennsylvania 15222. This material is in a form suitable for reproduction.

From one of our young citizens came this earnest request (handwritten exactly as shown):

Gentlemen:

I need this material for a very speachal reason. I must have all the imformation that I ask. I hope this isn't too much trouble but I need this information or I'll be in trouble. Please send me these things:

4 books on coal in Pa.
4 books on the strip mining
4 books of Common Fossils of Pennsylvania
4 books on Common Rocks & Minerals of Pa.

Please send this imformation or I'll be cent to the Princibles office.

Thank you for your kindness
Please Please

Yours
Truly

P.S. Please send it or my feelings will be hurt or I'll be crying in you know where.

Thank you again.

How could we deny such a plea? Another satisfied "customer."

ON THE DEMISE OF A TRIMERUS (DIPLEURA) DEKAYI

by John H. Way, Jr.[1]

To those of you who are even vaguely familiar with fossils called trilobites, the specimen of Trimerus shown in Figure 1 may look a bit strange. In order to understand his particular situation, let us look at these unique creatures.

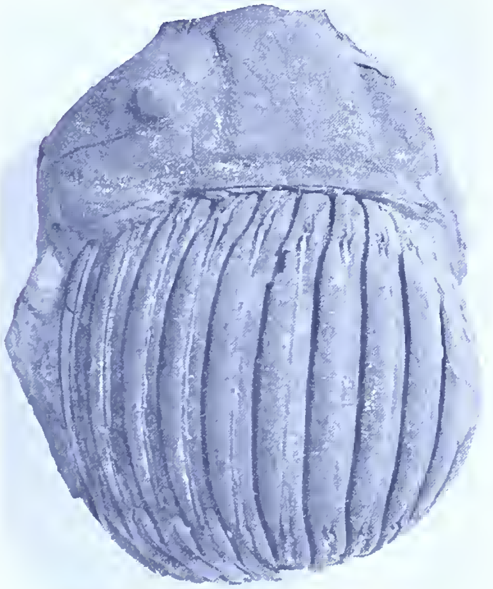


Figure 1. Specimen of Trimerus (Dipleura) dekayi from the Mahantango Formation near the Danville exit of I-80, Montour Co., Pa.

Trilobites belong to a large, highly varied and diversified group of animals called arthropods. This group is characterized by jointed arms, legs, and other appendages and comprises the insects, spiders, ticks, centipedes and millipedes, lobsters, crabs, shrimps, and barnacles. If we include both living and extinct animals, nearly 70% of *all* animal species belong to the arthropods; this involves at least 1 million species (Levi-Setti, 1975, p. 3). Originally the arthropods inhabited only the seas but, through time, they have adapted most efficiently to just about every possible environment imaginable. Statistically speaking, we are truly living in the age of arthropods.

Trilobites can be traced back 600 million years to the beginning of the Cambrian period when they suddenly appeared in the rock record as fully developed, specialized organisms. Unfortunately, no evidence for their presumed earlier existence has yet been found. It

[1] Pennsylvania Geological Survey

is probable that the ancestors of the trilobites had no hard parts to be preserved, but somewhere, Precambrian rocks must exist that contain traces of these arthropods.

During Cambrian time, trilobites specialized and diversified, and by the end of this period, 500 million years ago, they had reached their evolutionary peak. From that time on, it was all downhill, and they became extinct about 230 million years ago by the end of the Premian period. But for more than 400 million years the trilobite reigned supreme in the oceans that covered so much of the world at that time.

P. E. Raymond (1947, p. 47) noted that prior to the scientific study of trilobites, these natural curiosities were known as "petrified butterflies." Their elegantly ornamented coverings, striking symmetry, and relative rarity of complete forms has excited observers for decades and suggests that these creatures must have been truly remarkable. Trilobites tended to be small, averaging 2-7 cm (1-3 in.) in length, although fully-grown 3 mm- (1/10 in.) long specimens have been documented as well as some 70 cm (over 2 ft.) long, virtual giants among trilobites. Their habitat was exclusively marine, some choosing to crawl upon the sea floor, others were active swimmers, while still others channeled their talents in another direction and burrowed into the soft bottom sediments.

The name *Trilobita* originates from the three-fold division of the trilobite body into the axial lobe and the two more flattened, adjacent pleural lobes (Figure 2) and *not* from the separation of the skeleton into the three regions—the cephalon (head), thorax (body), and pygidium (abdomen) as is often, yet incorrectly, believed.

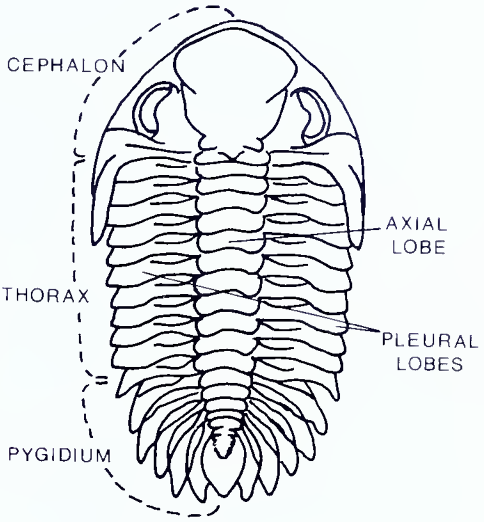


Figure 2. Trilobite skeleton with the three lobes indicated (1 axial lobe, 2 pleural lobes) as well as the 3-fold division of the entire skeleton.

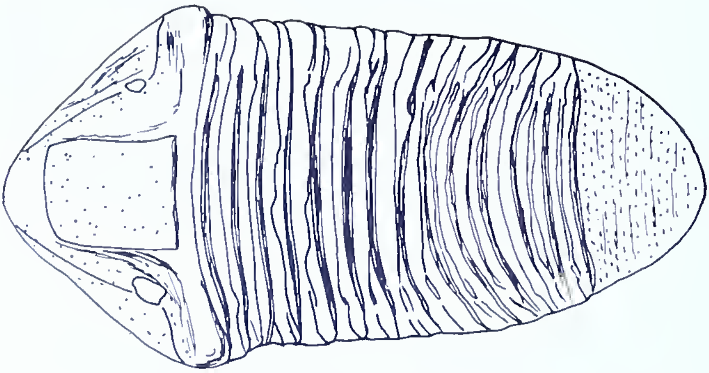


Figure 3. Trimerus (Dipleura) dekayi as it should look. Note that in this genus, the axial lobe is not present.

The body of the trilobite was completely encased in a protective chitinous skeleton (an exoskeleton). This exoskeleton was rigid, and growth of an individual could only take place through shedding or moulting of this armor covering. One individual, therefore, could have produced several fossils during his lifetime because it is this covering and not the soft parts of his body that becomes part of the fossil record (except under certain, very special conditions [Levi-Setti, 1975, p. 194, 195]). In addition, when the individual died, his final exoskeleton also had a chance for preservation.

This now allows us to speculate as to how our specimen met its fate. You will note that its head has rotated 90° and is now alongside the body (Figure 1, 3). The most probable explanation is that this fossil probably represents an exoskeleton that broke apart during the actual shedding process and was quickly burried and preserved in place.

This particular specimen was found at the base of the shale-chip debris slope developed in an exposure of Devonian age Mahantango Formation. Further information on the Mahantango Formation and its fossils is available in the Survey's report G 48 by R. L. Ellison and fossil collecting localities throughout the state are listed in another Survey publication, G 40, by D. M. Hoskins.

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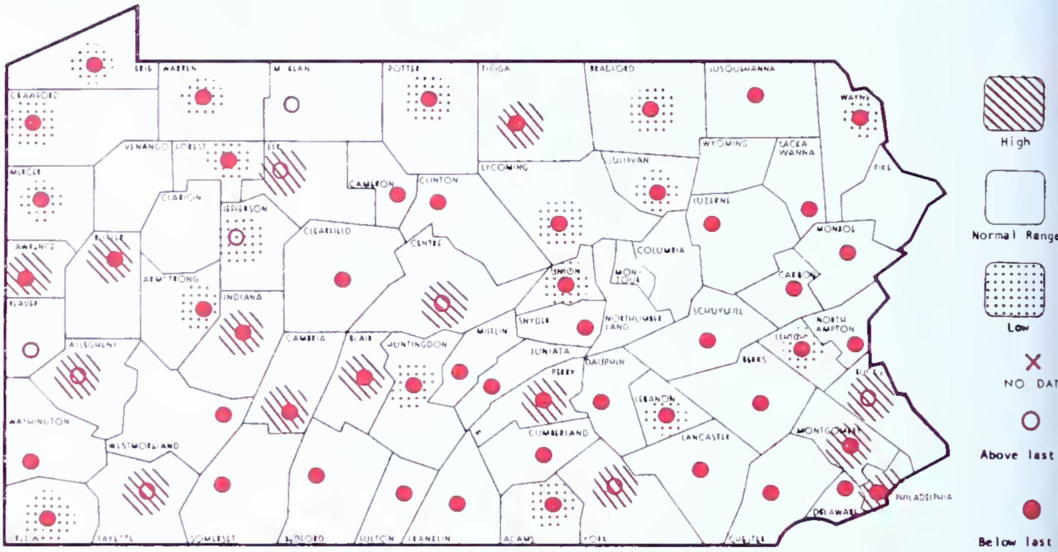

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ON THE COVER: A house is not a home! Disastrous result of landsliding at Height Drive, Shaler Township, Allegheny County. Note piers into bedrock; "Pittsburgh red clay shales," Casselman Formation, Conemaugh Group. Slide started spring, 1976. Photo by Jesse Craft.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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AUGUST 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

WANTED: SOLUTIONS

I've never been one for papering my walls with slogans. But events of recent months have caused me to think back to one slogan that made an impression on me years ago: ARE YOU PART OF THE PROBLEM OR PART OF THE SOLUTION? Our society has long been a reactive society; we respond to situations after they arise. And the situations we respond to most vehemently are usually the ones we don't like. And so it has been in recent years that many have vehemently expressed dislike for such events as the mine land spoilage, water pollution, the Vietnam War, government corruption, air pollution, inflation, energy shortages, rising taxes, rising crime rates, nuclear power, declining public and business morality, etc. It is not difficult to support or sympathize with movements which express opposition to such activities which jar our sensibilities, threaten our health or impose upon our lifestyle. There is even a social and psychological lift as we join in a formal or informal group in opposition. People apparently do like to participate in a cause, especially a cause against something.

But being against something does not solve the problem. What is needed is more public response with solutions, with constructive responses. To be against air pollution is trite, unless we as individuals come up with the technology and the willingness to pay for avoiding air pollution. To be against energy shortages is meaningless unless we as individuals come up with specific proposals for either additional energy or less use. To be against declining morality is not constructive unless we as individuals initiate improvements.

Some of the events of recent years to which we have expressed opposition call for new policies or better principles. Some will call for new procedures or new technology. Many call for additional money. Whatever it is that each of us chooses to be concerned about, let's also keep in mind the corollary to the opening phrase above: IF YOU ARE NOT PART OF THE SOLUTION, YOU ARE PART OF THE PROBLEM.

Arthur A. Socolow

GEOLOGICAL RESEARCH IN PENNSYLVANIA
1979

INTRODUCTION

This publication is the twenty-second annual report on Geological Research and Publications in Pennsylvania. This is an attempt to list all current geologic research in Pennsylvania and includes persons and projects other than those of the Pennsylvania Geological Survey. Because of the extensive response and large number of projects reported to us, we have had to exercise editorial license to reduce the description of the research projects to fit our available space. We have also attempted to determine an anticipated completion date (ACD) for each project. The anticipated completion date is the estimate of the date when the author will complete his report; additional time for publication should be projected.

The listings are grouped into major categories of research to facilitate your search for information on a particular subject. Reports published are listed by author.

As with all compilations, there may be omissions; this is unintentional. Additional copies of this report may be obtained by writing to the Bureau of Topographic and Geologic Survey, Department of Environmental Resources, P. O. Box 2357, Harrisburg, Pennsylvania 17120.

RESEARCH IN PROGRESS

AREAL GEOLOGY

S. S. ALBRIGHT, L. E. WILLIAMS, and KAREN FLINN, New Jersey State Museum. Source Identification and Differentiation of Argillite (and Associated Rocks) Used by New Jersey Indian Populations [Triassic Lockatong Fm. in N.J. and exposures of the same adjacent to the Delaware River in Pa.]. Determination of areal variation within the Lockatong Formation of New Jersey and Pennsylvania will permit identification of raw material sources utilized for stone tool manufacture by Indian groups from ca. 4000 B.C. to ca. 1000 A.D. ACD: 1981.

T. M. BERG, A. A. SOCOLOW, D. M. HOSKINS, A. R. GEYER, Pa. Geol. Survey, S. I. ROOT, Esso Products, W. E. EDMUNDS, Consultant, D. B. MacLACHLAN, W. D. SEVON, A. D. GLOVER, and R. T. FAILL, Pa. Geol. Survey. Revision of Pennsylvania State Geologic Map. Compilation maps for the revision have been placed on open file at the Survey's headquarters in Harrisburg. Publication scheduled for 1980.

M. J. BERGIN, U. S. Geol. Survey, Northern Anthracite Field. Investigations under this project are carried on intermittently. Current work consists of geologic map compilation for Kingston, Pittston, and Wilkes-Barre West quadrangles. ACD: Continuing.

HERBERT BLODGET, NASA, GREGORY SMITH and WILLIAM BRAGONIER, R & P Coal Co., and DAVID O'HARA, Island Creek Coal Co. Potential Use of Remote Sensing for Mine Roof Stability, Indiana and Armstrong Cos., Pa. A cooperative project between NASA and R & P Coal Co. to determine if remote sensing techniques can be used to predict mining conditions and patterns of sedimentation. ACD: Dec. 1979.

R. T. FAILL, A. D. GLOVER, and J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Blandburg, Tipton, Altoona, and Bellwood Quads., Blair, Cambria, Centre, and Clearfield Cos., Pa. Mapping of bedrock units from Cambrian to Pennsylvanian in age, surficial units (alluvium), structures in the Valley and Ridge province and Allegheny Plateau province, with discussion of the stratigraphy, structure, economic deposits, engineering properties, and environmental characteristics. ACD: 1979.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Bloomsburg and Mifflinville Quads. and Part of the Catawissa Quad., Columbia Co., Pa. ACD: 1979.

P. T. LYTTLE, U. S. Geol. Survey. Newark 2° Quad. Mapped areas will be field checked and reconnaissance mapping will be conducted in unmapped areas of Precambrian and Lower Paleozoic terrane in northern New Jersey. Special detailed studies will be made of klippen in Kittatinny Valley and Precambrian rock-Paleozoic rock interfaces.

Also, detailed investigations will be done of structure and internal stratigraphy of Hamburg klippe in eastern Pennsylvania. ACD: 1982.

D. B. MacLACHLAN, Pa. Geol. Survey. Geology and Mineral Resources of the Reading and Birdsboro Quads., Berks Co., Pa.

H. W. SCHASSE and T. M. BERG, Pa. Geol. Survey. Geology and Mineral Resources of the Conyngham Quad., Luzerne and Schuylkill Cos., Pa. ACD: Dec. 1980.

W. D. SEVON and T. M. BERG, Pa. Geol. Survey, and L. D. SCHULTZ, Gilbert Commonwealth, Inc. Geology and Mineral Resources of Pike Co., Pa. ACD: 1980.

J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Washington and Millville Quads., Montour, Columbia, and Northumberland Cos., Pa. Geologic mapping of bedrock and surficial deposits, defining and sampling materials with possible economic potential, and describing environmental and engineering characteristics of all geologic units in the area. ACD: Winter 1980.

G. H. WOOD, JR., U. S. Geol. Survey. Southern Anthracite Field. Compilation of geologic map of anthracite-bearing rocks in Nesquehoning quadrangle in Carbon County is in process of being completed. ACD: Continuing.

ECONOMIC GEOLOGY

R. C. ANDREWS and G. H. MYER, Temple Univ. Ground Magnetic and Gamma Ray Spectrometer Survey of Uranium Bearing Pegmatites in the Coatesville—Wagontown, Pa. Area. Gamma ray survey results indicate 3 areas of anomalous radiation, with uranium assay values as high as 60 ppm. Magnetic results indicate these areas may be interconnected at depth, yielding one large continuous body. ACD: May 1979.

T. M. BERG, A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. Coal Resources of Greene, Washington, Allegheny, Westmoreland, and Fayette Cos., Pa. Available data for coal-bearing strata of Greene and Washington Counties have been assembled and prepared for computer entry into the National Coal Resources Data System (NCRDS). Data for Allegheny, Westmoreland, and Fayette Counties are now being assembled and prepared for entry. Coal reserve maps and tables, along with a wide variety of other derivative maps, will be produced when the output capabilities of NCRDS at the U. S. Geological Survey in Reston, Va., are operational. ACD for Allegheny, Westmoreland, and Fayette Cos.: June 1980.

E. C. T. CHAO, U. S. Geol. Survey. Coal Petrochemistry and Related Investigations. Upon delivery and installation of an automatic image analysis system, effort will be made toward testing, calibration, and development of procedures for quantitative modal analysis of coal macerals and inorganic components. Routines developed will make possible rapid and more accurate completion of petrologic investigation of Upper Freeport coal in Pennsylvania. ACD: Continuing.

DONALD CONTE and JOHN TOMIKEL, California State Coll. Luzerne Twp.: Fayette Co. Strip Mining. Research project for master's degree concerning extent of stripping and legal problems involved. ACD: May 1979.

J. R. DUNN and G. M. BANINO, Dunn Geoscience Corp. Appraisal, Summit Quarries, Inc. [Summit Station, Pa.]. Quality, quantity, accessibility, and marketability evaluated. Discounted cash flow analysis of probable production used to determine value. Plant, campsite, ponds, buildings also appraised (subcontracted to appraisers). ACD: Mar. 1, 1979.

J. R. DUNN and G. M. BANINO, Dunn Geoscience Corp. Appraisal, Wayne Crushed Stone Co. [Scranton and Lake Ariel, Pa.]. Quality, quantity, accessibility and marketability evaluated. Discounted cash flow analysis of probable production used to determine value. Plant, buildings, real estate also appraised (subcontracted as appropriate).

THOMAS GRIFFITH and DONALD THOMPSON, California State

Coll. Methane Gas in Coal Seams. Thesis project for master's degree. ACD: May 1979.

J. A. HARPER and K. D. ABEL, Pa. Geol. Survey. The Dunkirk and Pipe Creek Organic-Rich Shale Facies (Upper Devonian) of Pennsylvania [NW Pa.]. Study is a portion of the resource evaluation study of the Eastern Gas Shale Project. Involves detailed investigation of the Dunkirk and Pipe Creek facies, their stratigraphic and structural relationships to the Devonian section, and their history and future potential for production of natural gas. Work utilizes geophysical (gamma ray) logs for correlation. Results will be published as cross sections, isopach, structure and lithofacies maps and reports. ACD: Nov. 1979.

A. G. HARRIS, U. S. Geol. Survey. Conodont Maturation Index—Devonian Shales. Project will continue to provide conodont age determinations and organic maturation assessment of samples from Devonian black shales in Appalachian Basin in support of projects within the Eastern Gas Shales program. ACD: Continuing.

J. W. HOSTERMAN, U. S. Geol. Survey. Appalachian Basin Devonian Shale Clay Studies. X-ray diffraction analysis to identify clay mineralogy and bulk semi-quantitative mineralogy is being done on approximately 1,500 samples from Alabama, Tennessee, Kentucky, West Virginia, Virginia, Pennsylvania, Ohio, and New York. ACD: Continuing.

G. W. LENEY, U. S. Dept. of Energy, and BENDIX FIELD ENGINEERING CORPORATION. National Uranium Evaluation Program. Programs include uranium resource evaluation of the Scranton, Harrisburg, and Williamsport quadrangles, and hydrogeochemical and stream sediment reconnaissance of the Newark, Harrisburg, and Williamsport quadrangles. ACD: Mar. through Nov. 1979, depending on project and quadrangle.

B. J. O'NEILL, JR., and J. H. BARNES, Pa. Geol. Survey, and K. J. LILES, U. S. Bureau of Mines. Properties and Uses of Shales and Clays in South-Central Pa. [Bedford, Blair, Centre, Fulton, Huntingdon, Juniata, Mifflin, Perry, Snyder, and Union Cos.]. A continuation of the series of programmed studies to evaluate the economic potential of clay-shale raw materials for ceramic and nonceramic uses. ACD: Dec. 31, 1979.

B. J. O'NEILL, JR., and FIELD MAPPING DIVISION, Pa. Geol. Survey, and U. S. BUREAU OF MINES. Investigations for High-Calcium Limestones in Pa. Objectives are: (1) to sample and analyze limestone units where information is lacking, incomplete, or widely scattered; (2) to map any newly discovered, high-calcium limestone unit that has a potential for commercial extraction; and (3) to synthesize the data into publications which will be useful guides to exploration targets. ACD: Continuous.

R. G. PIOTROWSKI, Pa. Geol. Survey. Medina-Tuscarora Stratigraphy and Gas Production [subsurface, western Pa.]. Relationship of the regional stratigraphy of Medina-Tuscarora to known natural gas production to determine the geological constraints upon production and to evaluate future potential. ACD: Oct. 1980.

A. W. ROSE, STEVEN HOWE, SCOTT TREGASKIS, and HIROSHI OHMOTO, The Pa. State Univ. Zinc-Lead Deposits in Lower Paleozoic Rocks of Central Pa. The Zn-Pb occurrences of Morrison Cove, Bedford County, are localized by faulting. Fluid inclusions show temperatures of about 150°C and highly saline brines; sulfur isotopes are similar to Mississippi Valley-type deposits. ACD: Aug. 1979.

A. W. ROSE and A. T. SMITH, The Pa. State Univ. Geology and Geochemistry of Uranium Prospects in the Catskill Fm. of Central and Eastern Pa. The geological and geochemical characteristics of all known uranium prospects in the Catskills are being investigated, with emphasis on regional stratigraphy, regional and detailed sedimentology, geochemical conditions, and other controls of the deposits. ACD: Sept. 1979.

J. W. SCHMOKER, U. S. Geol. Survey. Borehole Gravity Survey, Devonian Black Shale, Appalachian Basin. Will continue to obtain, digitize, and analyze gamma-ray and density logs for about 30 widely scattered locations in New York, Pennsylvania, Ohio, West Virginia, Kentucky, and Virginia. These wire-line data will be used to calculate organic contents for selected stratigraphic units and Devonian shale section as a whole, and will be related to uranium geochemistry, thermal maturity, clay content, and depositional framework of Appalachian Devonian black shales. ACD: Continuing.

R. C. SMITH, II, and J. H. BARNES, Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma Ray Reconnaissance Data for the Reading Prong, Eastern Pa. [portions of Berks, Lehigh, Northampton, and Bucks Cos.]. Aerial gamma ray data, collected as part of the NURE reconnaissance survey for the Dept. of Energy, is being interpreted for the Reading Prong portion of the Newark 1° x 2° quadrangle. Following a ground survey of the anomalous areas, representative samples will be collected for petrographic and trace element studies. ACD: Nov. 1980.

R. C. SMITH, II, Pa. Geol. Survey, and D. T. HOFF, William Penn Memorial Museum. Geology and Mineralogy of Copper-Uranium Occurrences in the Picture Rocks and Sonestown Quads. Each Cu-U occurrence located is being described and channel-sampled. Assays for Cu and U, as well as semi-quantitative trace element analyses, are in progress. Trace amounts of primary and secondary arsenic minerals have been found to be widespread and trace vanadium secondary minerals have been detected for the first time in the area. ACD: Late 1979.

K. J. WENRICH-VERBEEK, U. S. Geol. Survey. Uranium Daughter Products in Modern Decaying Plant Remains, Soils, and Stream Sediments. Current work includes data interpretation, correlation, and statistical analysis of sediment and organic data from studies conducted in Arizona, New Mexico, Colorado, Utah, Montana, Maryland, Pennsylvania, Virginia, and West Virginia; statistical analysis of available uranium data on stream sediments, soils, and organic material in RASS system and from literature; continued sampling of peat bogs to determine whether they can better be used than water sampling in alpine environments for uranium exploration; soil study to determine if soils are useful for exploration in area where uranium occurrences are known but relatively undisturbed. ACD: 1979.

PETER ZUBOVIC, U. S. Geol. Survey. Collection and Chemical Analysis of Coal Samples from U. S. Coal Resources. During the year, between 600 and 650 coal samples will be collected from major coal-producing areas east of the Mississippi River and chemically analyzed for 60-80 major, minor, and trace elements. X-ray mineral analysis will be performed on about 500 selected low-temperature coal ashes, and about 400 samples will be ashed by low-temperature techniques preparatory to mineral analysis. ACD: Continuing.

ENGINEERING GEOLOGY

A. R. GEYER, JESSE CRAFT, and J. P. WILSHUSEN, Pa. Geol. Survey. Engineering Characteristics of the Rocks of Pa. (2nd ed.). Project covers geologic, engineering, and groundwater characteristics of each rock formation described on the 1980 State Geologic Map. Material will be presented in outline form and is intended as a supplement to the new state geologic map. ACD: 1981.

ENVIRONMENTAL GEOLOGY

L. J. BACHMAN and R. R. PARIZEK, The Pa. State Univ. Environmental Geology of the Moshannon Valley Region, Centre and Clearfield Cos., Pa. [Philipsburg, Osceola Mills, Pa., and vicinity]. A study relating the geology, hydrology, and soils of a coal mining area to the suitability of parts of that area for different kinds of development, including coal mining, housing, commercial development, and other community development. The report includes a water table map, a geologic map, including new detailed mapping of a portion of the Sandy Ridge quadrangle, and land use suitability maps. ACD: June 1979.

G. M. BANINO and L. M. SETRIGHT, Dunn Geoscience Corp. Hydrogeologic Investigation of Proposed Cement Kiln Dust Disposal Area [Lehigh Valley]. A preliminary geologic and hydrologic study of a thick till sequence has led to preliminary approval. Installation of monitoring wells and design of the facility are in progress. ACD: June 1979.

N. K. FLINT, Univ. of Pitt., and BRUCE FERGUSON, Consultant. Natural Resources Inventory of Fox Chapel Borough, Allegheny County, Pa. ACD: Summer 1980.

S. P. GARABEDIAN and R. R. PARIZEK, The Pa. State Univ. Determining Factors in Streambed Infiltration in the Anthracite Coal Fields [Shenandoah and Mahanoy City, Pa.]. This project entailed gauging two losing streams in the Western Middle Anthracite Coal Field. Correlations were made between estimated streambed permeabilities from sediment analysis and the calculated permeabilities from the seepage runs with some success. ACD: June 1979.

GENERAL GEOLOGY

R. P. FRANKE, Pocono Environmental Education Center. Geology: The Earth in Motion. An introductory geology program for youngsters and adults in an experiential learning curriculum. Presently covers glaciation, weathering, mountain building and fossilization. At a later date it will include soil building and rock identification. ACD: June 1979.

J. P. WILSHUSEN, Pa. Geol. Survey. Geology of the Appalachian Trail in Pa. [SE Pa.]. The geology of the trail includes a description of characteristics of each geomorphic section with detailed, illustrated accounts of points of interest along the trail route. Sketch maps with geologic cross sections and descriptions at specific points are keyed to a geologic map of the trail. ACD: Jan. 1980.

GEOCHEMISTRY

C. B. CECIL, R. W. STANTON, W. CRAIG, R. B. FINKELMAN, and F. DULONG, U. S. Geol. Survey. Geology of Contaminants in Coal [western Pa.]. The project is designed to determine the geologic factors that control major, minor and trace element variation in the Upper Freeport coal of western Pa. Tentatively, the bulk of the non-pyritic ash content is of plant origin. ACD: Oct. 1980.

G. E. CLAYPOOL, U. S. Geol. Survey. Organic Geochemical Source-Bed Studies, Devonian Black Shale, Appalachian Basin. Amount and composition of natural gas generated from organic matter in Devonian black shale of Appalachian Basin will be estimated, and thermal stability of methane at high temperatures in these rocks will be investigated. Simulation of gas generation will be done by laboratory experiments. ACD: 1981.

A. W. ROSE and ELLEN KARASEVICH, The Pa. State Univ. Radium and Uranium in Limonites as a Guide to Uranium Ores [eastern and north-central Pa.]. ACD: Sept. 1979.

A. W. ROSE and JOSEPH McNALLY, The Pa. State Univ. Groundwater as a Geochemical Prospecting Medium for Lead-Zinc Ores in Carbonate Rocks [Chambersburg-Waynesboro area]. About 100 groundwaters are being analyzed for lead-zinc, fluorine and major elements and compared with waters from zinc prospects near Lancaster to test this exploration technique. ACD: Mar. 1980.

A. W. ROSE, SIMON PIRC, CHRISTY BELL, and PETER TOLE, The Pa. State Univ. Uranium and Thorium in Sedimentary Rocks Near Sandstone-Type Uranium Deposits [Pa. and Colo.]. The upper-most Catskill Formation near Jim Thorpe is slightly enriched in uranium and thorium relative to lower units of the Catskill and laterally equivalent beds, and was apparently formed of U and Th-rich detritus. ACD: Dec. 1979.

GEOMORPHOLOGY

W. B. WHITE, The Pa. State Univ. Pa. Caves. A catalog of the known caves of Pennsylvania including physical description maps and geologic interpretation is being prepared. The chapters on Centre and Huntingdon Counties were completed during the year. ACD: Fall 1979.

W. B. WHITE and E. L. WHITE, The Pa. State Univ. Studies of the Appalachian Karst [all Appalachian limestone terrains]. Unique landforms are developed on limestone terrains whose physical characteristics vary systematically with rock type, structure, and climate. The forms of Appalachian karst landforms are measured, the measures analysed, and related to the process of solutional modification of the landscape. Study regions are chosen from the entire Appalachian highlands, Pennsylvania to Alabama. ACD: 1984.

GEOPHYSICS

S. S. ALEXANDER, The Pa. State Univ. Pennsylvania Seismic Monitoring Network (NE U.S. seismic network). Principal objectives of contract are: to establish a regional seismic network centered in Pennsylvania to monitor local seismic activity; to collect base-line data on spatial and temporal distribution of seismic events; to identify and distinguish local earthquakes from quarry blasts; to calibrate the region with regard to travel-time curves; to construct seismicity maps for Pennsylvania and surrounding areas and relate patterns to structural features and tectonic stresses; and to work cooperatively with other network operators to establish overall patterns of seismicity.

B. F. HOWELL, JR., The Pa. State Univ. Earthquake Expectancy in Pa. Predictions are being calculated of average return periods of earthquakes of different intensities in whole state and individual locations. ACD: 1979.

C. K. SCHARNBERGER, Millersville State Coll. Seismicity of Southeastern Pa. Location of epicenters by seismograph and intensity reports; correlation with geologic structure. ACD: Open-ended.

VICTOR SCHMIDT, H. B. ROLLINS, JACK DONAHUE, MICHAEL PAYNE, STEVE SHULIK, and RICHARD LEE, Univ. of Pitt. Carboniferous Magnetostratigraphy of the Appalachian Basin. Main purpose of the project is to locate excursions (i.e. reversals, secular variation) within the magnetic record suitable for intra- and interbasinal time correlations; coupled with characterization of magnetization as a function of different lithologies.

GLACIAL GEOLOGY

E. B. EVENSON and JIM COTTER, Lehigh Univ., LES SIRKIN, Adelphi Univ., and W. D. SEVON, Pa. Geol. Survey. Wisconsinan Deglaciation Chronology of Northeastern Pa. and Northwestern N.J. The study concentrates on mapping Wisconsinan deglaciation deposits in the investigation area. The project will attempt to establish a radiocarbon controlled deglaciation chronology by dating organic matter recovered from bogs and lakes in the study area. Palynology will be used in an attempt to obtain the oldest organic matter for dating.

R. P. FRANKE, Pocono Environmental Education Center. Glacial Features Around PEEC. A display consisting of charts, posters, and a 350 pound striated rock shows the role which glaciers played in shaping the land. A model showing land and water features during glacial periods is under construction. ACD: June 1979.

F. T. HSU, Gilbert Associates, Inc. A Landslide Study in the Vicinity of the Tioga-Hammond Lakes, Tioga Co., Pa. This study was undertaken to evaluate potential landslide areas adjacent to the Tioga and Hammond dams, outlet works and reservoirs that could jeopardize the safety of the foregoing features or cause damage to contiguous areas. ACD: May 1979.

D. E. MARCHAND, U. S. Geol. Survey. Quaternary Studies, Central Susquehanna Valley [not an official U.S.G.S. project]. ACD: 1979.

JACK RIDGE, and E. B. EVENSON, Lehigh Univ. The Quaternary Geology of the Great Valley in Pa. and N.J. Near the Terminal Moraine [Northampton Co., Pa.; Warren Co., N.J.]. A morphologic sequence mapping of the glacial deposits has revealed evidence for one pre-Wisconsinan and at least five Wisconsinan "sequences." Provenance (pebble, gravel) and ice striation data will provide information on Wisconsinan ice flow. Clay and heavy mineral weathering in soil groups will hopefully provide a relative age differentiation and correlation with deposits of the Pocono Plateau. ACD: June 1980.

W. D. SEVON, Pa. Geol. Survey, and G. H. CROWL, Ohio Wesleyan Univ. The Late Wisconsinan Border in Northern Pa. ACD: July 1979.

HYDROLOGY

E. S. BAIR and R. R. PARIZEK, The Pa. State Univ. Numerical Simulation of the Effect of Open-Pit Anthracite Mining on the Ground-Water Flow System in Part of the Southern Anthracite Field [Southern Anthracite Field, Tamaqua region]. Pumping-test data, base-flow recession data, core porosity and permeability data, and water-level data were used in both a 2-D finite difference map-view model and a 2-D finite difference cross-section model to predict the effect a proposed 5700′ x 3200′ x 900′ open-pit anthracite mine would have on the local and regional ground-water flow system in part of the Southern Anthracite Field. The model is being used to calculate ground-water inflow rates into the pit, estimate seepage forces on the pit floor, and the possible dewatering effects on local and municipal water supplies. ACD: Dec. 1979.

A. E. BECHER, U. S. Geol. Survey, and L. E. TAYLOR, Pa. Geol. Survey. Hydrogeology of the Great Valley in Franklin Co., Pa. ACD: Jan. 1980.

D. F. KIBLER, E. L. WHITE, W. R. DeTAR, and E. J. PARTENHEIMER, The Pa. State Univ. Irrigation Study III [Pa.]. A water availability map based on minimum flow data is being constructed. This map should indicate the maximum water which may be mined from surface streams for use in irrigation. ACD: Dec. 1979.

SHEILA ROEBUCK and R. R. PARIZEK, The Pa. State Univ. Predicting Groundwater Flows to Underground Coal Mines in Pa. Geologic and hydrologic variables will be related to mine discharge data. Statistical analyses will determine significant associations and be used to develop regression equations that can estimate groundwater inflow rates to mines for various settings of western Pennsylvania. ACD: Dec. 1979.

D. W. ROYER and L. E. TAYLOR, Pa. Geol. Survey. Summary Groundwater Resources of Adams Co., Pa. ACD: Sept. 1980.

R. A. SLOTO, U. S. Geol. Survey. Effect of Urbanization on the Quantity and Quality of Ground Water and Low Streamflow in Warminster Twp., Bucks Co., Pa. The effects of urbanization in southeastern Pennsylvania on the quantity and quality of ground water and low streamflow and their relationship will be examined. ACD: Sept. 1980.

R. A. SLOTO and L. J. McGREEVY, U. S. Geol. Survey. Development of a Digital Model of Ground-Water Flow in Deeply Weathered Crystalline Rock, Chester Co., Pa. A digital model of ground-water flow in the Upper Pickering Creek basin, Chester County, has been developed. The model simulates the effects of potential development on the hydrologic system. ACD: Mid 1979.

J. H. WILLIAMS and R. R. PARIZEK, The Pa. State Univ. Hydrogeology of the Danville Area, Pa. Study includes mapping of bedrock and surficial geology, water-table mapping, aquifer evaluation, and delineation of hazards to the hydrologic environment. ACD: Aug. 1979.

C. R. WOOD and G. N. PAULACHOK, U. S. Geol. Survey. Ground-Water Quality and Flow in the Coastal Plain Aquifer, Philadelphia, Pa. ACD: Sept. 1981.

IGNEOUS AND METAMORPHIC PETROLOGY

W. A. CRAWFORD, Bryn Mawr Coll. Geology of the Honey Brook Upland, Piedmont, SE Pa. A mapping petrologic, geochemical study to aid in the unraveling of the geologic history of this metamorphic terrain.

A. A. DRAKE, JR., R. I. TILLING, and P. T. LYTTLE, U. S. Geol. Survey. Petrochemistry and Radiogenic Heat Producing Minerals in Precambrian Rocks of Reading Prong [Pa., N.J., N.Y.]. Work this year will be concentrated in the north-central part of the Prong. ACD: 1982.

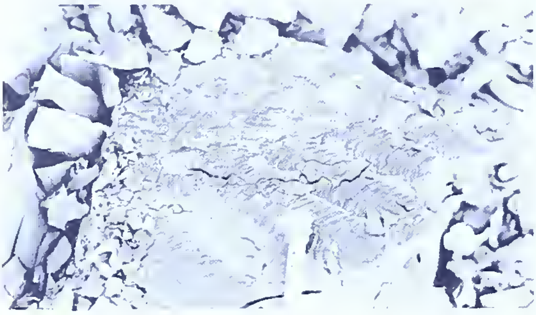
WILLIAM SCHRYBA and G. H. MYER, Temple Univ. Amphibolite Units of the Wissahickon Fm. [Delaware and Philadelphia Cos.]. ACD: Jan. 1980.

MINERALOGY

J. H. BARNES, Pa. Geol. Survey, W. F. DOWNEY, JR., and R. B. FINKELMAN, U. S. Geol. Survey. Mineralogy Associated with Burning Anthracite Deposits [Luzerne, Schuylkill, and northern Dauphin Cos.]. Study of minerals forming from sublimation of gases produced by subsurface fires in anthracite mines and waste piles. ACD: 1979.

R. B. FINKELMAN and M. E. MROSE, U. S. Geol. Survey. Characterization of New Minerals from the Surfaces of Burning Culm Banks [anthracite and bituminous regions]. ACD: 1981.

M. E. MROSE, U. S. Geol. Survey. Mineralogical Investigations. Will continue mineralogical and crystallographic study of minerals found associated with burning culm banks in Pennsylvania and study of Nd-rich carbonate hydrate from Saucon Valley, originally described as "lathanite." Search for suitable crystal of ajoite for crystallographic and structural studies continues. ACD: Continuing.



PALEONTOLOGY

E. B. GIFFIN, Wellesley Coll. Lower Silurian Gnathostomes from Pa. [Perry Co.]. ACD: 1980.

D. M. HOSKINS, Pa. Geol. Survey. Fossil Collecting in Pa. (2nd ed.). Progress on reexamining sites in the first edition is slow; many have been constructed over and many are now not publicly available. Search for alternate sites has not been very rewarding.

W. F. KLOSE, II, Paleontological Research Inst., and FRANK CARPENTER, Curator of Paleozoic Insects, Museum of Comparative Zoology, Cambridge, Mass. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvanian age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. ACD: Ongoing.

W. A. OLIVER, JR., U. S. Geol. Survey. Systematics and Biostratigraphy of Corals from Keyser Limestone [Pa., Md., Va., W.Va.]. ACD: 1982.

D. C. PARRIS and S. S. ALBRIGHT, New Jersey State Museum. Silurian and Devonian Fossils and Fossil Sites in the Delaware Water Gap National Recreation Area. This project will be a compilation of paleontologic information for use in the interpretive activities of the National Park Service. ACD: Sept. 30, 1980.

ALFRED TRAVERSE and V. F. MUTTI and other students, The Pa. State Univ. Palynological Zonation of Middle and Upper Devonian Rocks of Central Pa. ACD: Uncertain.

ALFRED TRAVERSE, The Pa. State Univ., and P. K. STROTHER, Harvard Univ. Plant Remains from Silurian Rocks of Pa. [central Pa.]. ACD: 1980.

SEDIMENTOLOGY

EDWARD COTTER, Bucknell Univ. Environments of Deposition of the Tuscarora Fm. and Clinton Group (Silurian) in Central Pa. ACD: Spring 1981.

J. C. FERM, Univ. of S. Car., W. A. BRAGONIER, Rochester & Pittsburgh Coal Co., and GEORGE PEDLOW. Guide to Cored Rocks of the Pittsburgh Basin. Several thousand core samples from diamond drill holes were sampled and grouped into lithologically similar groups. Samples from each lithologic group were photographed and assigned a 3-digit lithologic code. A guidebook to the cored rocks will be assembled from the photographs. ACD: Dec. 1979.

ED HOHOS, Rochester & Pittsburgh Coal Co. A Paleoenvironmental Model of the Upper Freeport Coal Seam and Associated Rocks, Indiana and Armstrong Cos., Pa. Developed a model that describes the depositional environment at the time of Upper Freeport coal formation. Related the thickness, extent, and quality of the coal to the depositional environment. Model used to predict coal character. ACD: May 1979.

W. D. MARTIN, L. L. Y. CHANG, D. C. BENTON, M. A. THOMSEN, and D. J. WEIMER, Miami Univ. Petrology of the Mudstones and Shales of the Dunkard Group (Upper Pennsylvanian and Permian) of Pa., W.Va., and Ohio. The rock facies, paleoslope and environments of accumulation of the Dunkard sediments have been delineated. Two belt-type, and some smaller, sandstone units have been mapped and petrology determined. This research is directed to the fine clastics. ACD: Aug. 1980.

S. T. PAXTON and E. G. WILLIAMS, The Pa. State Univ. Textural and Mineralogical Modifications in Sediments as a Function of Coal Rank [Pa.]. ACD: 1980-81.

A. M. THOMPSON, DAVID GOLIKE, and SUSAN HALLAM, Univ. of Delaware. Sedimentological Studies of Upper Ordovician Clastic Lithologies in Central Pa. [Valley and Ridge belt west of Susquehanna River]. Project (1) uses sandstone lithology and paleontology to interpret Martinsburg-Reedsville basin evolution, and (2) traces lithofacies in relation to Juniata-Tuscarora color boundary. ACD: 1980.

STRATIGRAPHY

T. M. BERG, Pa. Geol. Survey, and W. E. EDMUNDS, Consultant. The Huntley Mountain Formation of North-Central Pa. A new formation including the nonmarine transitional sequence between the Catskill Formation and the Burgoon Sandstone is being named. The formation has its type section at Huntley Mountain near Waterville, Pa. It has been mapped over about 4,000 square miles for the new state geologic map. ACD: Late 1979.

PING-FAN CHEN, W. Va. Geol. & Economic Survey. Lower Paleozoic Stratigraphy, Tectonics, Paleogeography, and Oil/Gas Possibilities in the Central Appalachians. Paleogeography. ACD: 1979. Oil and gas possibilities. ACD: 1981.

W. J. CLARK, Rochester & Pittsburgh Coal Co. Upper Freeport Depositional Model [western Pa.]. A depositional model for the Upper Freeport coal has been developed for a 14 x 26 mile study area. Patterns emerge to explain splitting, thinning/thickening, and/or absence of coal. ACD: June 1979.

A. D. GLOVER, C. H. DODGE, V. W. SKEMA, and J. R. SHAULIS, Pa. Geol. Survey. TASIC (Temporarily Available Stratigraphic Information Collection). This project is a continuing program for the recovery of stratigraphic data from active coal and clay strip mines while exposures are available. The long-term project is designed to provide data for future mapping and regional mineral resource evaluation. ACD: Continuing program.

P. W. GOODWIN, E. J. ANDERSON, R. R. LEE, and GABRILLE LaROCHE, Temple Univ. Punctuated Aggradational Cycles (PAC's) in Ordovician, Silurian, and Devonian Sequences [central Pa.]. Application of PAC hypothesis to Appalachian Paleozoic stratigraphy. Primary emphasis on Helderberg carbonates. One goal is detailed event-correlation from W. Va. to Mohawk Valley, N.Y. ACD: Long-term project.

J. C. GRIESEMER and J. D. RYAN, Lehigh Univ. A Petrographic Study of the Sandstones and Conglomerates in the Mauch Chunk-Pottsville Transition in NE Pa. Objectives are to better assign the Mauch Chunk-Pottsville contact and to better understand the source(s) of these rocks. ACD: Summer 1979.

J. A. HARPER and R. G. PIOTROWSKI, Pa. Geol. Survey. Stratigraphic Correlation of Surface and Subsurface Middle and Upper Devonian, SW Pa. Middle and Upper Devonian stratigraphic units in the subsurface of Pennsylvania are correlated to surface units by use of geophysical (gamma ray) and lithologic logs. Subsurface nomenclature is taken largely from Eastern Gas Shales Project studies. Explanations are given for delineating strata on gamma ray logs. ACD: Oct. 1979.

LOUIS HEYMAN, Pa. Geol. Survey. The Ridgeley Formation in the Subsurface of Pa. The subsurface Ridgeley Formation is defined by geophysical log markers. Delineation of the unit, a subsurface section showing lithic variations in the unit, and map showing the extent and thickness of the unit and percent sandstone are planned. ACD: Sept. 1979.

M. R. RODGERS, Univ. of Pitt. Stratigraphy and Structural Geology in the Broadtop Coal Field of Pa. The purpose of this master's thesis is to determine stratigraphic and structural relationships within the Broadtop coal field, with emphasis on the coal units. ACD: Apr. 1981.

J. B. ROEN, U. S. Geol. Survey. Stratigraphy of the Devonian Black Shales in the Appalachian Basin. Studies are still continuing in order to establish a regional stratigraphic framework and delineate areal extent, thickness, and structure of Devonian black shales and related rocks of Appalachian Basin to facilitate a complete characterization study and hydrocarbon resource appraisal. ACD: Continuing.

T. O. WRIGHT, Allegheny Coll., and G. C. STEPHENS, George Washington Univ. Clastic Ordovician Rocks of Pennsylvania [Martinsburg outcrop belt, Pa.]. Project involves detailed mapping of the

Martinsburg Shale and associated rocks in Pennsylvania to establish biostratigraphic and lithostratigraphic frameworks for these rocks. Petrographic and sedimentologic analyses are being done to refine the area's geologic history. ACD: 1980.

STRUCTURAL GEOLOGY

P. W. G. BROCK, Queens Coll. of CUNY. Structural Relationships between the Precambrian and Paleozoic Rocks in and Adjacent to the Reading Prong [mostly on the N.J. side but including the west bank of the Delaware River]. Structural data are being accumulated in the course of teaching geology field courses in the area.

A. A. DRAKE, JR., P. T. LYTTLE, G. A. SCARNAUACK, MICHAEL TAYLOR, and J. E. REPETSKI, U. S. Geol. Survey, and G. G. LASH and ROBERT KASTELIC, Lehigh Univ. Central Appalachian Tectonic History (Newark 1° x 2° quad.). A study of the evolution of the central Appalachians as a type mountain range, particularly the role played by each of the major orogenies, their interrelations, and possible plate models. ACD: 1982.

R. T. FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Map will display: 1) location, extent and name of each of the major folds and faults; 2) prominent joint orientations; 3) contours on top of basement; 4) outcrop trace of Old Port Formation, and important angular unconformities; 5) structure contours on top of Onondaga in western and north-central Pennsylvania; 6) igneous bodies; 7) tectonic and metamorphic boundaries; 8) radiometric dates with locations; and 9) earthquake epicenters. ACD: June 30, 1980.

L. D. HARRIS, U. S. Geol. Survey. Structural Studies of the Devonian Black Shale in the Appalachian Basin. Compilation and analysis of regional joint data, Landsat lineaments, and their relationship to the regional structural pattern are continuing. ACD: Continuing.

L. D. HARRIS, U. S. Geol. Survey. Thrust Fault Deformation and Hydrocarbon Entrapment. Initial work under this reactivated project will be analysis of thrust fault deformation in Valley and Ridge and in adjacent Appalachian Plateau in order to document and establish geologic controls for present-day distribution and changes in structural style, and to construct a regional tectonic model that will be used in evaluating location and geometry of structural traps available for hydrocarbon accumulation. ACD: Continuing.

G. G. LASH, Lehigh Univ., A. A. DRAKE, JR., and P. T. LYTTLE, U. S. Geol. Survey. Structure and Stratigraphy of the Autochthonous and Allochthonous Rocks of the Hamburg and Kutztown Quads. A three-pronged structural analysis of the parautochthonous Lehigh Valley sequence, allochthonous Hamburg Klippe, and post-Ordovician rocks in order to differentiate different deformational phases. ACD: June 1980.

C. K. SCHARNBERGER, Millersville State Coll. Geologic Structure and Magnetic Anomalies in Southern Lancaster Co., Pa. Detailed mapping of magnetic anomalies using ground-based magnetometer and investigation of relationship to structure along the "Martic Line." Also, mapping and structural interpretation of diabase dikes in the same area.

A. M. THOMPSON, Univ. of Delaware. Modern Seismicity and Brittle Structural Evolution of the Piedmont-Coastal Plain Boundary in Mid-Atlantic States [eastern Pa., Del., Md., N.J.]. Project is coordinating geological, geophysical and photolineament information with distribution of modern seismicity to establish probability of Recent faulting in area of high density of nuclear reactors. ACD: 1981.

REPORTS PUBLISHED

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BRETSKY, P. W., 1978, Gradual species replacement in the Mahantango shales (Middle Devonian, central Pennsylvania). GSA Abstracts with Programs, v. 10, no. 7, p. 371.

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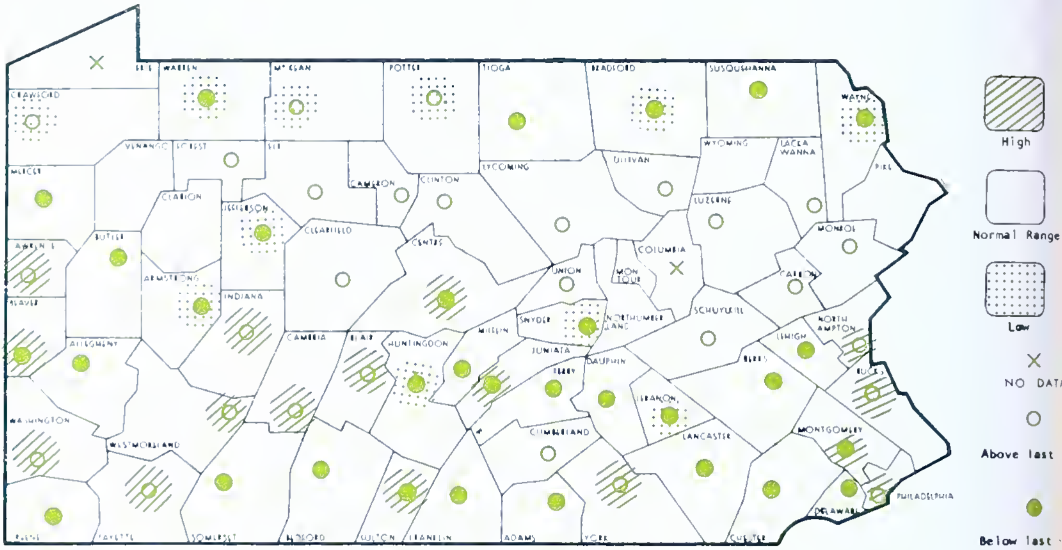

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ON THE COVER: Anticline and syncline fold structures in the northern limb of the western Middle Anthracite Field. Commonly referred to as the Ashland Anticline, this feature is located 0.8 mile south of Pa. Route 61 and 54 in the Borough of Centralia, northeast of Ashland Borough.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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OCTOBER 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

OUR COAL: PROBLEMS AND HOPE

Recent news reports of the lethargic production record currently being manifested in the coal fields of Pennsylvania (actually, all of Appalachia) point up a basic truism for any mineral resource: Regardless of the availability of reserves, the utilization and economic success of a mineral resource depends upon the market demand. The anticipated and much desired increased demand for Pennsylvania and Appalachia coal has not materialized, despite the heralded objective to become less dependent upon foreign oil.

For purposes of corrective action and as a lesson in mineral economics, it is worth a look at the causes of the coal market and production malaise. The reasons are many and the ones being cited here are not necessarily in order of importance: (1) The demand for electricity has been lower than expected and thus the demand for our coal, providing 75% of Pennsylvania's electric generation, is lower than expected. (2) There has not developed either the economic incentive or government requirement to cause oil-burning power plants to convert to coal use. (3) Federal air quality standards greatly limit the use of our coal (because of its sulfur content) in the populous areas of our state where the potential use for coal is greatest to supply industry and electric generating needs. To date, the techniques for dealing with the coal-sulfur problem have proved to be both extremely costly and mechanically unreliable. (4) The cost of mining coal has increased significantly due to the procedures and technology required by governmental environment protection laws and regulations. Higher cost coal in the face of a weak market does not make for impressive production records. (5) The cost of opening new mines or expanding the capacity of existing ones, is astronomical. Underground mines, which are needed to get at the large deep reserves of coal available in Pennsylvania, could cost well over $100 million each, to cover the price of equipment and mine development even before any coal would be produced. At current high interest rates, coupled with an uncertain market demand for coal, plus a federal energy policy that is neither clear nor final, plus environmental constraints upon production, all combine to discourage the necessary large financial investments needed to expand or modernize coal production capability. (6) Lag time should be mentioned here because it impacts upon the ability of coal production facilities to respond to expansion, modernization, or installation of environmental protection equipment. From the time planning begins for

(Continued on page 13)

Arthur A. Socolow

MINERALS IN PENNSYLVANIA COAL

R. B. Finkelman, F. T. Dulong, R. W. Stanton, and C. B. Cecil
U.S. Geological Survey, Reston, VA 22092

Coal, a combustible sedimentary rock, is commonly believed to consist primarily of degraded organic matter but may, in fact, contain substantial amounts of minerals. Minerals constitute the bulk of the ash or residue left upon combustion of the coal. By convention, in the United States, low-ash coal contains less than 8 percent ash, medium-ash coal, 8 to 15 percent, and high-ash coal, more than 15 percent. Material containing more than 33 percent ash is classified as coaly or carbonaceous shale, silt, etc. (personal commun. G. H. Wood, Jr.)

Samples of coal from Pennsylvania are currently being studied in an attempt to determine the mode of occurrence of elements of environmental interest (Cecil et al., 1979). These studies have revealed that the coal contains a diverse and interesting assemblage of minerals. Except for cleat fillings and rare nodules of marcasite, pyrite, or carbonates, most mineral grains in coal are quite small, far less than 1 mm in size.

X-ray diffraction analysis of coal ash after low-temperature oxidation (<150°C) of the whole coal indicates variable concentrations of kaolinite, illite, pyrite, and quartz in all the nearly 100 samples studied to date. Calcite, dolomite, siderite, marcasite, rutile, anatase, gypsum, coquimbite, mixed-layer clays, montmorillonite, and plagioclase feldspars have been detected in quantities ranging from rare to abundant in some of these samples.

The coal also contains an abundant suite of other less common or accessory minerals. Some of these accessory minerals have been extracted for mineralogic examination by grinding and handpicking or by density or magnetic separations. However, the most effective method of examination is by scanning electron microscopy of polished blocks of coal (Finkelman and Stanton, 1978). Table 1 is a list of the accessory minerals; several minerals are illustrated in Figures 1-3.

Although all these minerals are minor constituents in coal their relative abundances vary considerably. Some, such as the submicron gold particles, were observed in only one or two samples, whereas

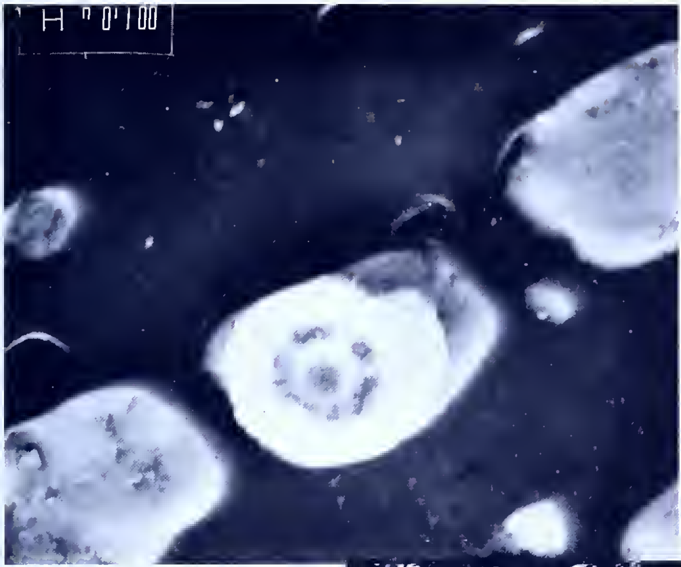

Fig. 1. Reflected light optical photomicrograph of birefringent marcasite in pyrite. Scale bar is 10 μm.

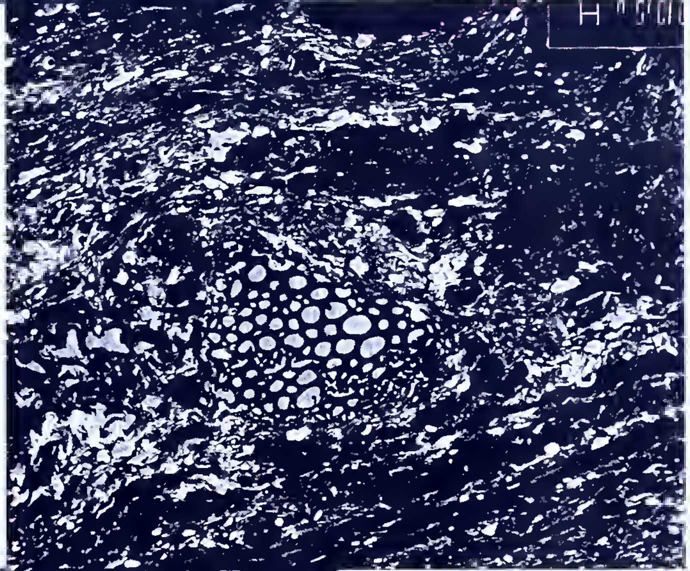

Fig. 2. Scanning electron photomicrograph of minerals (clays and quartz) in a polished block of coal. Scale bar is 10 micrometers.

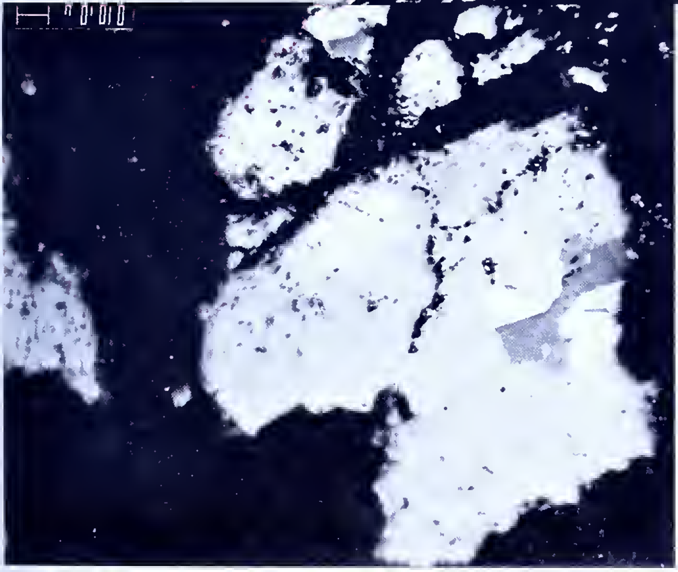

Fig. 3. Scanning electron photomicrograph of crandallite in kaolinite filled pores (plant cell lumen). Scale bar is 1 micrometer.

others were encountered in almost every sample studied. In Table 1 we have indicated the probable abundances for most of the accessory minerals. Several of the accessory minerals were not sought in every sample because they required special techniques to locate or to identify. No attempt was made to suggest relative abundances for these minerals.

The minerals listed were identified as the result primarily of examining samples of Upper Freeport medium volatile bituminous coal collected from the Homer City #1 and Lucerne #6 mines in Indiana County, PA.; samples from other Pennsylvania bituminous and anthracite coal beds were studied less intensively. Therefore, this list is not comprehensive, and undoubtedly many other minerals exist in Pennsylvania coal.

Table 1 *Accessory Minerals in Pennsylvania Bituminous Coals*

[Quotation marks indicate that the identifications have been based primarily on major element data and should be considered as tentative; *, also found in Pennsylvania anthracite; +, new to Pennsylvania; A, common; B, rare; C, very rare.]

	"Ankerite"	B
*	Apatite	A
	"Argentite"	C
	"Barite"	A
*	Chalcopyrite	A
	"Chromite" (?)	C
	"Clausthalite"	A
	Chlorite	A
	Corundum	
	Crandallite	A
*	Diaspore	B
	"Elemental gold"	C
*	"Galena"	C
	"Gorceixite"	B
	Halite	
	Hematite	
	Ilmenite	B
*+	"Linnaeite group"	C
	Magnetite	B
*	"Monazite"	A
	Opal	
	"Potash feldspars"	A
	Pyrrhotite	
	"Pyroxene group"	B
+	Siderotil	
*	Sphalerite	A
*	"Witherite"	C
	"Xenotime"	A
*	Zircon	A

A knowledge of minerals in coal is useful in predicting the behavior of trace elements during combustion, gasification, and liquefaction and is a primary aid in deducing geological history of a coal. A study of minerals in coal such as this, not only adds substantially to information about Pennsylvania's most important mineral resource but also adds important data to the rich mineralogical lore of Pennsylvania.

Acknowledgements

We thank our colleague Jean Minkin for reviewing this note and for contributing data from her study of minerals in Pennsylvania coals. Gordon H. Wood, Jr., also of the U.S. Geological Survey, substantially improved the note with his comments.

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WESTERN CRAWFORD COUNTY GEOLOGY AND GROUNDWATER REPORT

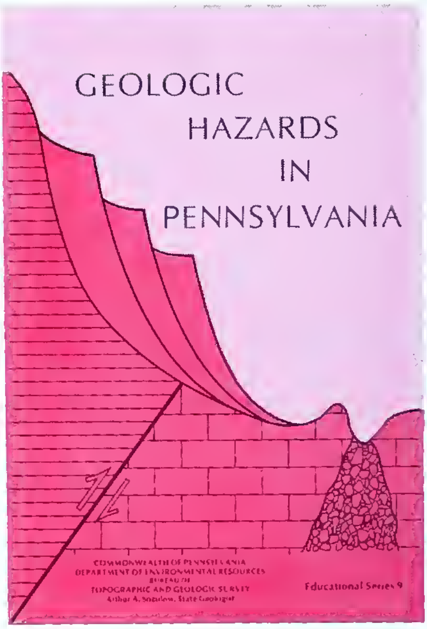
The character of the rock formations and the nature of their contained water have a definite impact on utilization of land. As a developing area where industry and recreation are expanding, it is most appropriate that the geology and groundwater resources of western Crawford County be recorded and available to the public, local officials, planners, and environmentalists. To that purpose the Pennsylvania Geological Survey has published "Geology and Groundwater Resources of Western Crawford County, Pennsylvania," by George Schiner and John Gallaher. This project was carried out in cooperation with the U.S. Geological Survey.

The new report is complete with a 103-page text, plus large, detailed maps showing bedrock geology, unconsolidated glacial deposits, and groundwater availability. The report is designed to be easily usable and intelligible by those who need to deal with the geologic and hydrologic conditions of the area.

Bulletin W46, "Geology and Groundwater Resources of Western Crawford, Pennsylvania" is available from the State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125. The price is $12.50 (plus 75¢ for Pa. residents).

Geologic Hazards In Pennsylvania

Continuing its efforts to identify both favorable and problematical geological conditions as they affect the citizens of Pennsylvania, the Bureau of Topographic and Geologic Survey in the Department of Environmental Resources has published a new booklet entitled "Geologic Hazards in Pennsylvania" authored by J. Peter Wilshusen.



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HAZARDS
IN
PENNSYLVANIA

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Educational Series 9

Geologic hazards of various kinds are common to almost every area of the world. Natural geologic hazards that most commonly receive attention in different parts of the world are earthquakes, volcanic eruptions, landslides, and sinkholes. Since Pennsylvania is fortunately spared the disastrous effect of volcanos and earthquakes, the Commonwealth is not widely recognized as having any serious problems with geologic hazards. Yet, Pennsylvania annually suffers millions of dollars of damage and untold personal disruptions as a result of frequent and widespread occurrences of landslide phenomena and sinkhole collapses.

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Ladder-Back Ripples In The Catskill Formation

by Jon D. Inners and Philip J. Daly*

Ripple marks–i.e., subparallel ridges and hollows formed by waves or currents in sandy sediments—are probably the most common and easiest understood of the myriad depositional structures that occur in shallow water sedimentary rocks. Simple ripple marks are of two basic types: (1) symmetrical, or oscillation, formed by the back and forth motion of waves; and (2) asymmetrical, or current, formed by flow in one direction only. In addition, many complex variations of these common ripples have been described in the geologic literature (Kindle, 1917; Pettijohn and Potter, 1964). Not only are ripple marks valuable clues to deciphering the depositional environment of a particular rock sequence, but they also provide insight into the hydraulic regime of ancient streams–including current direction, water depth, flow velocity, etc.—and the wave dynamics along ancient shorelines. Complex ripple marks can also pose tantalizing questions as to their origin. Such a set of puzzling ripples has recently been found in the course of geologic mapping in the Bloomsburg-Mifflinville-Catawissa area.

The ripples occur near the top of an easily accessible rock outcropping on the east side of L.R. 415, just north of its intersection with L.R. 19014, about 1.25 km northwest of Mainville, Main Township, Columbia Co. (Figure 1) (Lat. 40°58′56″N, Long. 76°23′20″W, Catawissa quad.). Even though traffic on L.R. 415 is relatively light, visitors should be wary because of the narrow shoulder on the road adjacent to the outcrop. Parking for several vehicles is available on the opposite side of the road.

Rock exposed at the site consists of approximately 85 m of interbedded gray and red sandstone, siltstone and claystone provisionally assigned to the upper part of the Irish Valley Member of the Catskill Formation. The rock types are arranged in fining-upward cycles, with sandstone at the base and claystone or silt-clay laminite at the top (Figure 2). Such cycles are typically developed by meandering river systems: the basal sandstones are channel and point bar deposits; the medial fine sandstones and siltstones represent levee deposits; and the claystones and siltstones at the top are overbank, flood-basin deposits.

The complex ripple marks of interest (Figure 3) are found on a

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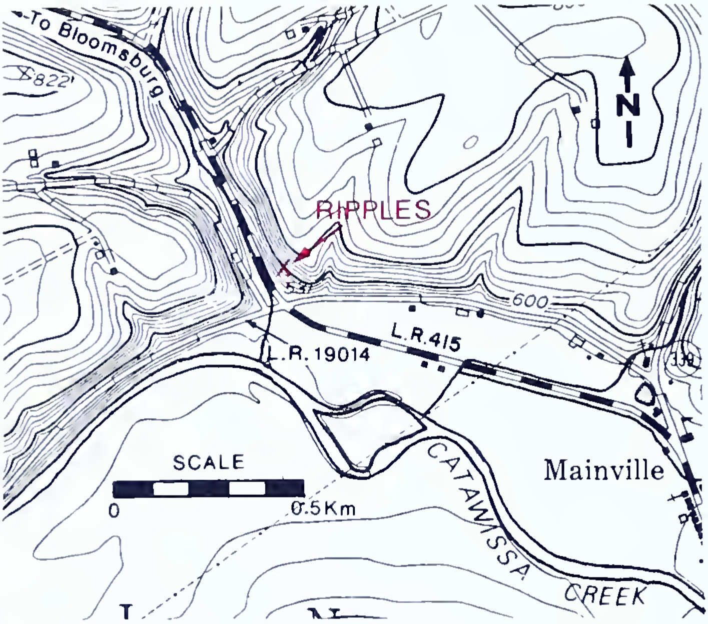

Figure 1. Location map.

single bedding plane in thin bedded, light grayish red, sandy, silt-clay laminite at the top of the upper cycle. They consist of an early formed set of asymmetrical ripples (steep face to the northwest) on which a later formed set of nearly orthogonal, small-scale symmetrical ripples has been superimposed. The symmetrical ripples are distinct in the troughs of the asymmetrical ripples but appear only as faint lines on the crests. Compound ripples of this general type have been referred to as "ladder-back" ripples (Anan and others, 1969). Several other nearby bedding planes contain only small-scale symmetrical ripples that trend roughly parallel to the small ripples of the complex set.

Important attributes of ripple marks bearing on paleogeographic interpretation include the wave length, wave height, trend, and asymmetry. For the two sets of ripples in question, these measurements are as follows:

	Wave Length	Wave Height	Trend (Fig.4)	Asymmetry
Asymmetrical	50 - 55 mm	4 - 5 mm	N54E	To NW
Symmetrical	7 - 8 mm	1 - 2	N41W	None

The current that formed the asymmetrical ripples flowed at right angles to the ripple trend in the direction of the steep ripple-face, i.e. toward N36W (Figure 4).

In recent sediments, ladder-back ripples are particularly characteristic of the intertidal zone; several types of diverse origin have been described from coastal areas in New England (Anan and others, 1969). Such ripples may form from shifts in current direction during

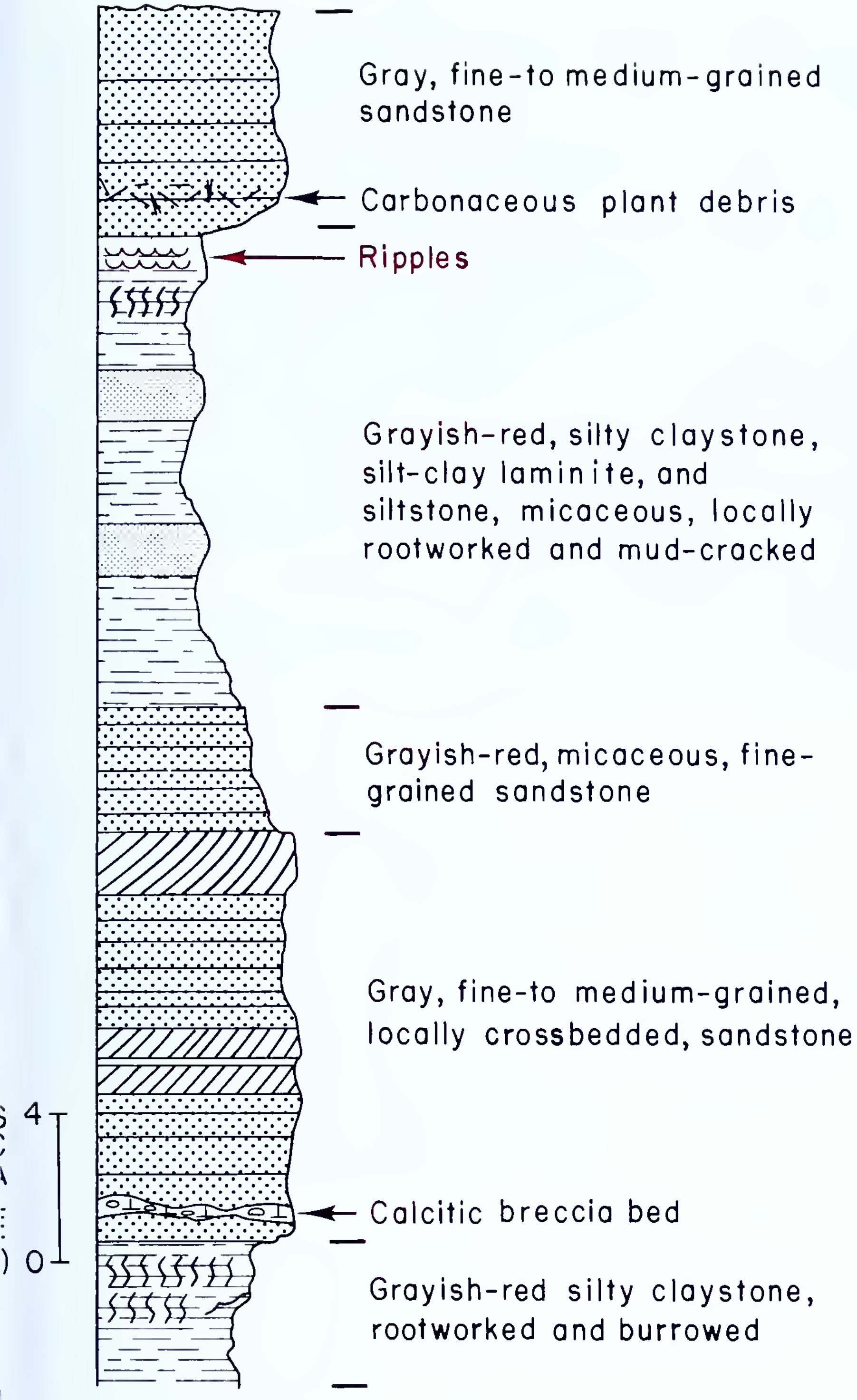
Gray, fine-to medium-grained sandstone
Carbonaceous plant debris
Ripples
Grayish-red, silty claystone, silt-clay laminite, and siltstone, micaceous, locally rootworked and mud-cracked
Grayish-red, micaceous, fine-grained sandstone
Gray, fine-to medium-grained, locally crossbedded, sandstone
Calcitic breccia bed
Grayish-red silty claystone, rootworked and burrowed
4
0

Figure 2. Fluvial fining-upward cycle with rippled silt-clay laminite at top, upper half (south end) of Mainville site. Another cycle similar to this is exposed immediately below at the north end of the cut.

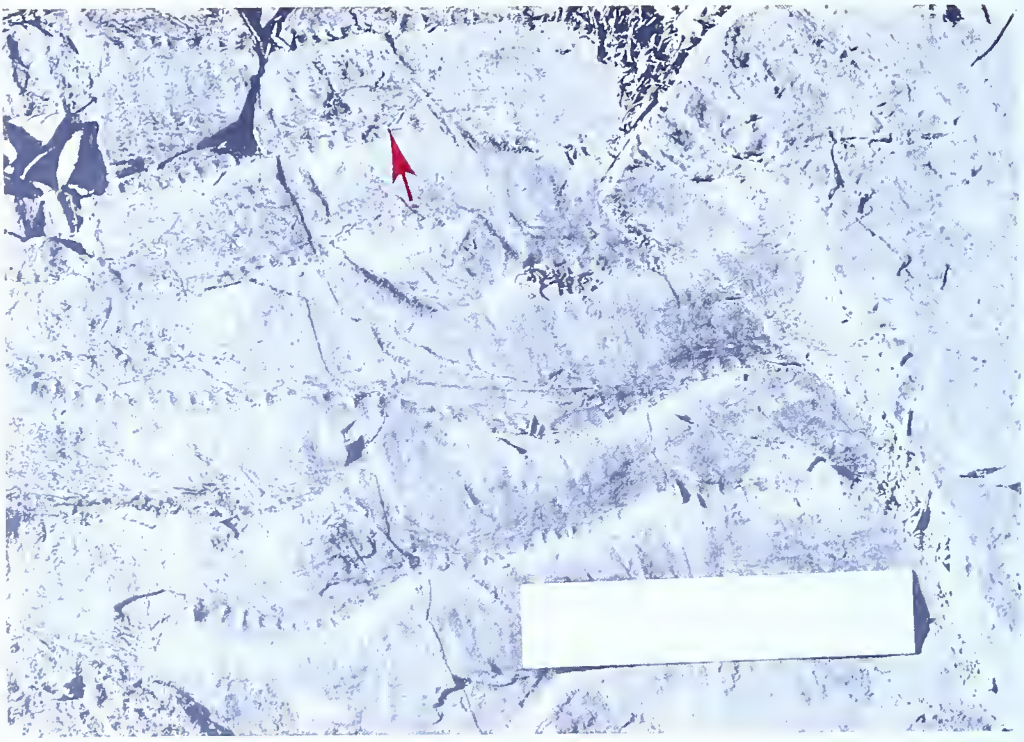

Figure 3. Ladder-back ripples in Catskill Formation. Arrow shows main current direction. Scale is 15 cm long.

of the sediments in which the ripples occur, it is perhaps entirely large ripples as the tide ebbs, or by the interaction of tidal currents and waves. Generally, however, these features are on a scale several times larger than the ripples in the Catskill Formation.

Compound ripple marks very similar to those illustrated here have also been described from ephemeral streams in Utah (Picard and High, 1970). In this case, asymmetrical ripples form first when flood water in the channel is deep enough to flow over marginal and channel sand bars. As the water level falls, downstream currents are refracted shoreward over the bars, and small-scale, nearly symmetrical ripples are formed at right-angles to the asymmetrical ripples.

But what of the paleogeographic implications of the ladder-back ripples in the Catskill Formation? The fining-upward cycles in the upper Irish Valley are probably non-marine fluvial cycles that formed upstream of a prograding shoreline on a muddy, coastal plain only a little above sea level. Although it is possible that there may have been some tidal influence in the deposition of these beds, particularly in the sandy channels, no presumptive evidence for tidal deposition (e.g. marine fossils) was observed at the Mainville site. The writers incline toward the view that the ripples formed in an extremely shallow, ephemeral rivulet in the flood basin adjacent to a large, low-gradient stream. Judging by the small scale and fine grain size different stages of the tidal cycle, by water flowing in the troughs of fortuitous that current direction defined by the asymmetrical ripples (i.e. N36W) lies almost exactly down the Late Devonian paleoslope. The symmetrical ripples may have formed either by refraction of very shallow currents or by wind agitation acting on small pools of water as the rivulet gradually dried up. The abundance of mudcracks in the red claystones and siltstones immediately adjacent to the rippled beds indicates that periodic desiccation was a characteristic feature of the depositional environment in which the ripples formed.

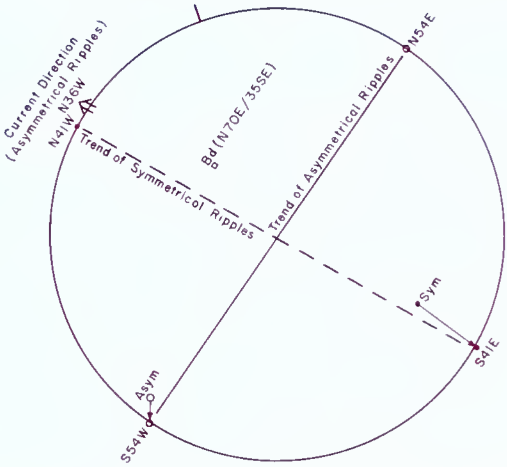

Figure 4. Stereographic projection of ripple lineations and pole to bedding. Bedding has been rotated to horizontal about bedding strike to arrive at original depositional trends of ripples.

Fining-upward cycles in the upper part of the Irish Valley and lower part of the overlying Sherman Creek Member of the Catskill Formation have long been the target of intense uranium exploration (McCauley, 1961; Sevon and others, 1978). The uranium minerals commonly occur in association with concentrations of carbonaceous plant fragments, similar to that at the base of the gray sandstone capping the Mainville exposures (Figure 2). In fact, several small adits, presumably dug out during the uranium boom of the late 50's, can be found in gray sandstone at the north end of the cut described here and at exposures a short distance to the west. The presence of ladder-back ripples in a potentially uranium-bearing sequence appears to provide yet another clue to the environmental framework of Catskill uranium occurrences.

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SURVEY ANNOUNCEMENTS

REPORT ON GEOLOGY AND SAFER COAL MINING

In keeping with the dedication of the Pennsylvania Department of Environmental Resources to make mining in Pennsylvania as safe as possible, the Bureau of Topographic and Geologic Survey has issued a new publication entitled "Geologic Conditions Affecting Safe Bituminous Coal Mining in Pennsylvania: Selected Papers."

Assembled by former staff geologist, Samuel I. Root, the new, 202-page book contains seven outstanding papers which identify various geologic conditions that create safety problems in coal mining. By learning to recognize those hazardous geologic conditions, it is then possible to take appropriate actions to eliminate or minimize the chances for mine accidents.

Among the factors discussed are the relationship of roof instability to methane in the mines, how to best orient mine tunnels when certain types of fractures exist, and the design and location of pillars in the presence of various rock depositional features. The new publication is an example of how the Bureau of Topographic and Geologic Survey is focusing on the ways that geology can help solve problems and serve the needs of the citizens of Pennsylvania.

"Geologic Conditions Affecting Safe Bituminous Coal Mining in Pennsylvania" is available as Information Circular 84 from the Pennsylvania State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125. The price is $2.80 (plus 6% sales tax for Pennsylvania residents).

COAL STUDY TO HELP EXPLORATION

In order to explore, evaluate, and develop Pennsylvania's coal resources, it is necessary to understand exactly how each of the coal layers was formed and by what criteria favorable localities may be located today. The results of such an investigation are reported in the latest publication released by the Pennsylvania Geologic Survey. Mineral Resources Report 75, "The Economic Geology of the Upper Freeport Coal in the New Stanton Area of Westmoreland County, Pennsylvania: A Model for Coal Exploration" was co-authored by Mark Sholes, William Edmunds, and Viktoras Skema. This report is a case study of a discrete area in which modern stratigraphic and sedimentologic concepts have been applied to evaluate the physical and chemical properties of the Upper Freeport and associated rocks.

With the availability of a great amount of data in the study area, the authors were able to compile detailed cross sections, isopach maps and structure contour maps. Analyses of these data resulted in depositional and paleogeographic models. It is believed that the results of this study will assist geologists and the coal industry to more effectively pursue the development of this and other coal formations of Pennsylvania.

Bulletin M 75, "The Economic Geology of the Upper Freeport Coal in the New Stanton Area of Westmoreland County" is available from the State Book Store, P.O. Box 1365, Harrisburg, Pennsylvania 17125. The price is $2.80 (Pa. residents add $0.17 tax).

OUR COAL: (continued from page 1)

such change, through the periods of technical design and approval, financial arrangements, ordering and receiving delivery of necessary hardware, installation and construction on site, there may elapse anywhere from 2 to 8 years, depending on the size of the project. Such lag time in the face of uncertain markets and the high price of necessary money, all contribute to depressing coal expansion and modernization.

The above list is not complete; it does not include the decline in skilled and willing manpower who would have to work in the underground coal mines needed to get the large remaining reserves of Pennsylvania coal. Neither does the list include problems of deteriorating coal transportation facilities.

Despite all the above, as economic geologists, *we are optimistic over Pennsylvania's long-range coal production prospects*. We are blessed with coal reserves that could accommodate our needs for over 200 years. These reserves are in our own "back yard," unbeholden to foreign quirks and upheavals. The constraints to production and expansion cited above, be they technical, financial, or governmental policy, are not insurmountable. It is well that the Administration of Pennsylvania is dedicated to getting on with the job of encouraging and stimulating the development of our vast coal resources. Such a positive approach is well likely to expand beyond our state boundaries and improve the contribution of coal in our national energy situation.

URANIUM MINERALIZATION AT EASTON, PENNSYLVANIA

by Richard I. Grauch, U.S. Geological Survey
Kenneth R. Ludwig, U.S. Geological Survey

A reconnaissance study of several uranium localities in Pennsylvania was made during 1975 and 1976 (Grauch and Zarinski, 1976) as a part of a U.S. Geological Survey investigation of the distribution and origin of uranium in the Reading Prong-Jersey Highlands-Hudson Highlands region. At that time Robert C. Smith II of the Pennsylvania Geological Survey showed one of us (R.I.G.) a newly discovered uranium occurrence at Quarry L near Easton (Smith, 1975, 1977; fig. 1 of this paper). As at three other Easton area occurrences, the predominant uranium phase is thorian uraninite disseminated in a host of serpentinized dolomitic marble, which Montgomery (1957) correlated with the Precambrian Franklin Formation. The quarry exposes a layered sequence of serpentine, dolomitic marble, tremolite-rich layers, and phlogopite-rich layers; the layering apparently mimics original compositional layering but has been stretched and shows boudins. Uraninite occurs in the podiform phlogopite-rich layers, although it is not everywhere present in these layers. Smith and Grauch collected a 3 1/2 m long channel sample across one of the uraniferous layers in quarry L, and results of a gamma ray spectrometric analysis of that sample show 503 ppm RaeU, 390 ppm Th, and 1.5% K (C. M. Bunker, analyst, U.S.G.S.). Smith (1977) reported a chemical analysis of a separate sample from the same channel that shows 360 ppm U. The discrepency between the two analyses does not necessarily suggest radiometric disequilibrium (as inferred by Smith, 1977) as analyses were performed on separate samples. Cubic crystals of uraninite with small octahedral faces as much as 3 mm on an edge were collected from the sampled layer. The unit cell of one of those crystals is 5.527 A, which suggests that some thorium and/or other impurities may be present.

Uranium and thorium occurrences in the Easton area have been known since the 1930's when Gehman (1936) found what he first believed to be uraninite and later described as thorianite at two localities, the Williams quarry (formerly the Sherrer quarry) and near the College Hill reservoir (Fig. 1). Gehman (1936) also described a yellow uranium mineral from an abandoned quarry on the Bushkill Creek; (this is probably either the Quarry L of Smith (1975) or Schweyer's quarry (Peck, 1911). The occurrence of uranium minerals at three widely spaced localities spanning a strike belt about 1 1/2 km led Gehman to speculate that economic quantities of uranium and thorium might occur at depth. In 1933 Wells and others published a description of some of Gehman's samples which they called the first authenticated thorianites from the United States. Their samples were unusually rich in uranium (Th/U = 1.07) and Wells and others (1933) informally proposed designating a mineral with the structure of thorianite but with a thorium-uranium ratio near 1 as uranothorianite. In another portion of the paper, they asserted that the mineral should be called thorianite. Montgomery (1957) described additional samples from Williams quarry and College Hill reservoir, as well as, a thorian uraninite from the Royal Green quarry in New Jersey (Fig. 1). He concluded that the predominant uranium mineral at the three localities is thorian uraninite; thorium content of six samples varies from 15 to 35% ThO_2.

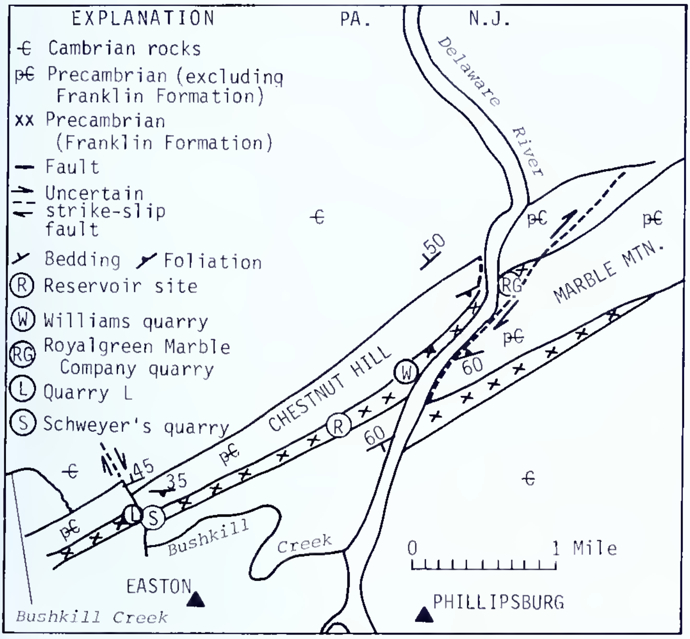

Figure 1. Sketch map of Easton area (modified from Montgomery,1957).

The origin of the uranium mineralization is not clear. Montgomery (1957) and Gehman (1936) both concluded that the uranium and thorium were derived from an acidic magma and were emplaced during a hydrothermal stage of pegmatite intrusion. Our preliminary observations made at Quarry L, which agree with observations made by Gehman and Montgomery at the other localities, suggest a strong stratigraphic (compositional) control on the distribution of uraninite. This does not negate the hydrothermal hypothesis, but does suggest the possibility of a synsedimentary origin for the uranium and thorium with subsequent crystallization of uraninite during metamorphism.

A split of our channel sample gives a $^{207}Pb/^{206}Pb$ age of 948 ±

5 m.y. (Table 1). The data of Table 1 show that the age is almost concordant, but that the sample has probably lost approximately 3% of its radiogenic lead. If this loss occurred within approximately the last 200 m.y., the $^{207}Pb/^{206}Pb$ age is a good estimate of the age of uranium mineralization. Based on the ratio of chemically determined lead to uranium and thorium, Wells and others (1933) concluded that the age of the thorianite from Williams quarry is 790 m.y. Based on the lead-alpha age of a presumably cogenetic zircon, Montgomery (1957) concluded that the age of uranium mineralization at the Royal Green quarry is 850 m.y. Considering the techniques used by these earlier workers, their determinations of the age of mineralization are surprisingly close to ours which are based on measurement of isotope ratios, a more reliable dating technique. Our age of approximately 948 m.y. agrees with a generally accepted Grenville thermal event in other parts of the Precambrian in the northeastern United States. The near concordance of the U-Pb ages suggests that there has been no intense thermal disturbance of the rocks at Quarry L since about 948 m.y. ago.

Table 1.—*Uranium and thorium content and isotopic ages of Quarry L sample*

[Analysis of sample 675-72, a totally digested 1 g split of ground, 200 g rock sample]

U(ppm)	1050
Th(ppm)	547
U/Th	1.9
$^{206}Pb/^{238}U$	920 ± 10 m.y.
$^{207}Pb/^{235}U$	928 ± 10 m.y.
$^{207}Pb/^{206}Pb$	948 ± 5 m.y.

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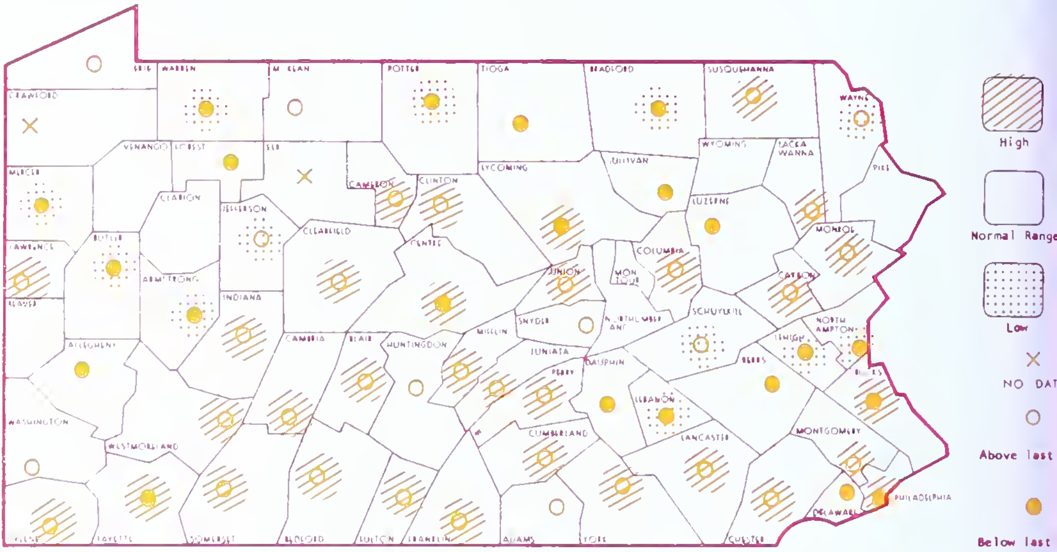

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VOL. 10/6

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ON THE COVER: Conneaut Lake in Crawford County; Pennsylvania's largest natural lake; 938 acres. A natural and recreational resource.
Photo courtesy of Bill Bolles, Dept. of Education.

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DECEMBER 1979

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

COAL IS OUR GOAL

As is appropriate for a geologic agency, much has been written in these columns about the extensive coal resources which Pennsylvania still has available within its boundaries. It may also be appropriate to point out how significant a role coal already plays in our state's economy and energy supplies.

In terms of Pennsylvania's total energy consumption, coal provides 45% of our energy needs, oil provides 34%, natural gas 17%, and nuclear power approximately 5%. Not only is coal the major raw material for our total energy needs, but it is important to note that 75% of our coal needs are provided from within our own state, whereas in the case of oil, natural gas, and nuclear, 88% to 100% of these energy raw materials are brought in from out of state.

Another statistic is worth noting: In the matter of electricity generated within Pennsylvania, coal is the fuel for 77% of our electric generation, nuclear fuel provides approximately 14%, oil 8%, and water power approximately 1% of our electric generation. Again we see the dominant role which our coal already plays in our state's power supplies.

With foreign oil resources more and more unpredictable in price and accessibility, we are indeed fortunate that within Pennsylvania's boundaries we have calculated there is well over 20 billion tons of recoverable coal reserves. At Pennsylvania's current rate of annual coal production of approximately 85 million tons, the recoverable resources can serve our needs for over 200 years. If we can overcome some of the economic, technical, and environmental obstacles to increased coal consumption, we could double our production and still have 100 years of coal reserves in our own "back yard." It is a goal worthy of our maximum efforts. The Bureau of Topographic and Geologic Survey is doing its utmost to provide data answers to the geological problems which remain to be resolved in order to stimulate both coal consumption and production.

Arthur A. Socolow

PENNSYLVANIA SHALE-CHIP RUBBLE

by W. D. Sevon and T. M. Berg

INTRODUCTION

Shale-chip rubble is a useful, but generally unfamiliar construction resource in Pennsylvania. Deposits of this material comprise accumulations of shale and siltstone chips and fragments that range from very small pebble size to cobble size. These deposits can be mapped with a minimum of field data using techniques of aerial photograph interpretation, and they are more widespread than geologists previously realized.

Shale-chip rubble deposits resulted from the downslope accumulation of fragments formed by natural disintegration of several different shale units in Pennsylvania (Fig. 1). These bedrock units principally include the Martinsburg Formation and the Hamburg sequence of the Great Valley, and the Antes, Reedsville, Marcellus, and Mahantango Formations of the Ridge and Valley. These shales are highly susceptible to natural disintegration because of numerous bedding and fracture partings (Fig. 2). The intersections of these surfaces are closely spaced and yield small fragments that are platy, chippy, and hackly. These fragments accumulated a long time ago on low to steep slopes, but mostly at the bases of the slopes. Vegetated slopes underlain by shale-chip rubble are very similar in form to shale bedrock slopes, and the deposits may easily be overlooked. However, careful inspection of tonal differences on aerial photographs can reveal their presence.

DESCRIPTION

The shale fragments are generally platy or chippy, but sometimes are pencil-like or very irregular (hackly). Fragments commonly range in size from 1/4 to 24 inches long, and up to 1 inch thick, but larger pieces occur. The deposits are crudely to moderately well-stratified (Fig. 1, bottom), and stratification is normally parallel to the slope surface. Stratification is the result of variations in fragment size, shape sorting, and clay matrix concentration. The fragments are arranged in either a coarsening-upward sequence or an alternating interbedding of coarse and fine fragments resulting from distinct size

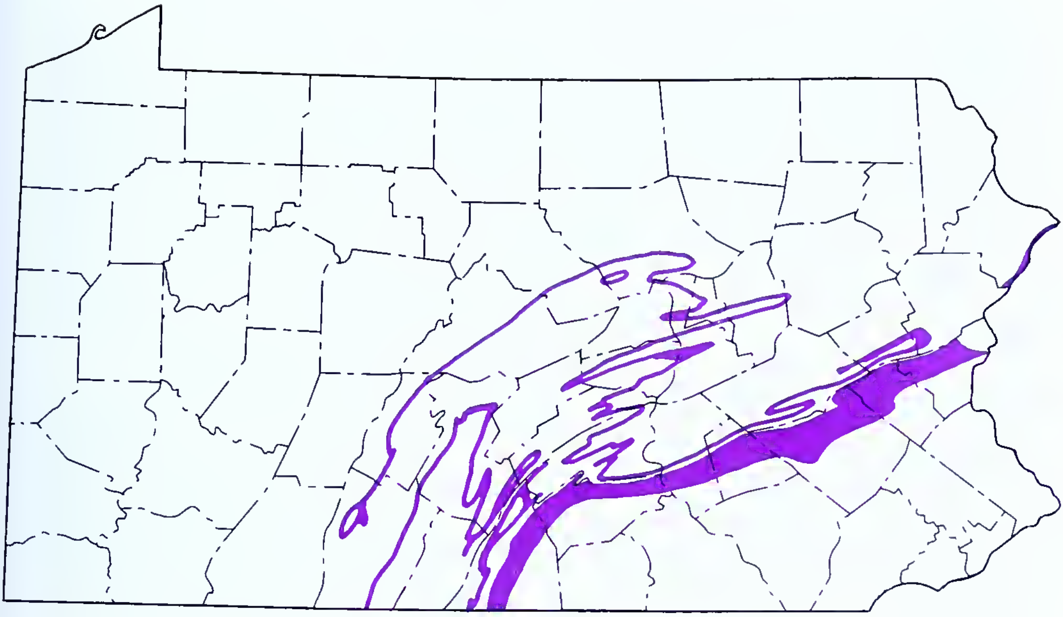

Figure 1. Areas of shale in Pennsylvania where shale-chip rubble is most likely to occur.

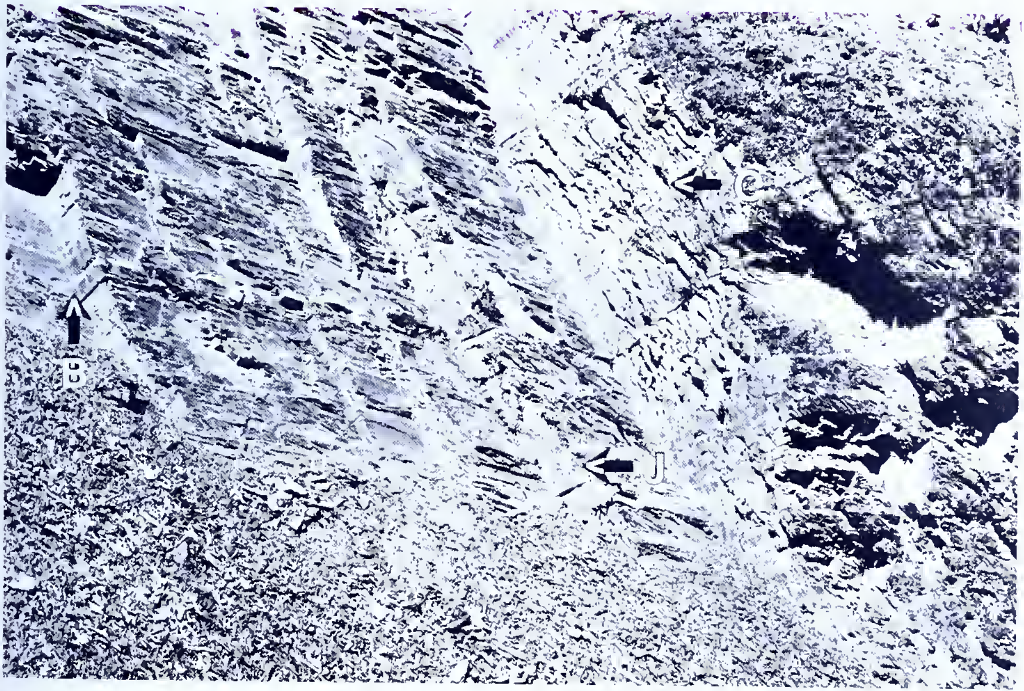

Figure 2. Surface of shale-chip rubble deposit below free face of Antes shale. Note abundance of joint (J), cleavage (C), and bedding (B) planes along which mechanical disintegration occurs.

sorting. The flat surfaces of platy fragments are subparallel to the slope surface, and are frequently imbricated. Long axes of elongate fragments are usually oriented downslope (Fig. 2, lower part).

The shale chips are subrounded to subangular. Although individual chips have a thin clay coating, the deposits have an open framework, are loosely coherent, and are generally well-drained. In color, the deposits vary from dark gray to moderate yellowish brown and yellowish gray.

Fragments in the upper 3 to 6 feet of some deposits are not parallel to the surface, but are oriented in a variety of whorls or prisms (Fig. 3). The fragments are generally chaotically oriented in the center of these structures, and oriented parallel to the structure curvature at its margin.

The deposits occur on the slopes of valleys, sometimes cover the valley floor, and are areally linear. The deposits are wedge-shaped in cross section with the thin edge on the slope at the upper end of the deposit, and the thickest accumulation approximately parallel with the valley floor. Maximum thickness of an individual deposit depends upon valley relief at time of origin and ranges from about 3 feet to more than 60 feet.

ECONOMIC SIGNIFICANCE

Shale-chip rubble has long been mined in many pits (Fig. 4), and commonly used as a fill material. It is sometimes called "chipstone" or "sharpstone," and has been referred to as shale-chip colluvium in some Pennsylvania Survey reports. We have observed its successful utilization as surfacing for low-use roads. The rubble has also been used quite effectively as an impervious backfill material when compacted around structures that may be within the reach of seasonal high water table. Tests run on this material by the Pennsylvania Department of Transportation indicate that it is suitable for shale embankments that can be compacted, in loose 8-inch layers, with normal heavy equipment conforming to their specifications.

Tests of a sample of shale-chip rubble from Monroe County in northeastern Pennsylvania yielded the following results: bulk specific gravity—2.61; absorption—4.22 percent; Modified Washington Degradation Factor—13.3; moisture-density relationship under compaction—maximum density of 122 lb/ft^3 with optimum moisture content of 13 percent.

Shale-chip rubble is easily mined using a front-end loader. The main problems associated with mining are: (1) failure of slopes oversteepened by mining, and (2) downslope movement of trees and other vegetation as a result of slope failure (Fig. 4).

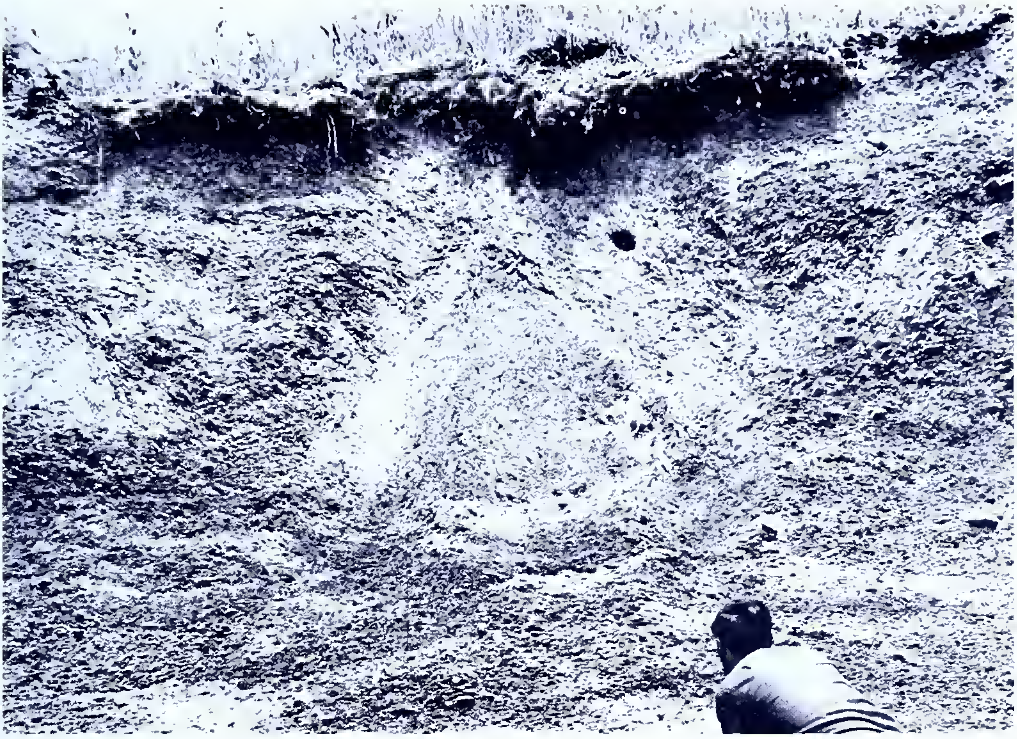

Figure 3. Inverted wedge developed by freeze-thaw distortion of shale-chip rubble formed from Martinsburg shale. Exposure is south of Jacksonville, Lehigh County.

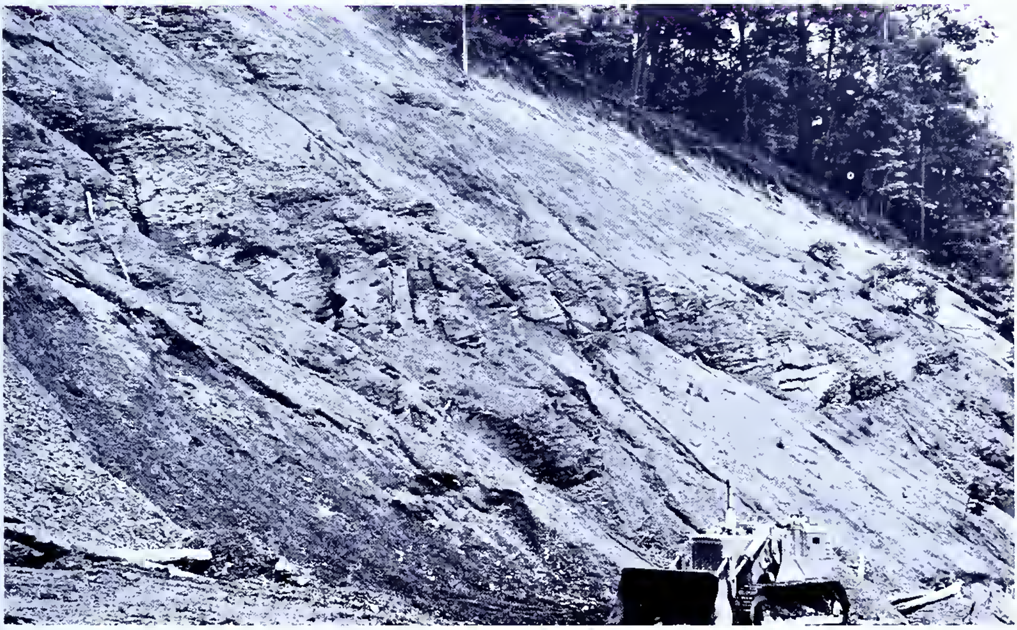

Figure 4. Large exposure of shale-chip rubble developed from Mahantango shale near Bushkill, Pike County.

ORIGIN

The origin of shale-chip rubble (grèzes litées of Europe) is generally associated with periglacial (near a glacier or in arctic regions) climatic conditions, but the exact process of deposition is not known. The processes of sheet flow (overland flow), mudflow, and solifluction are considered the most probable modes of deposition, but rockfall cannot be excluded.

The primary requirement for formation of shale-chip rubble is a sloping, vegetation-free exposure of suitable rock. The high, cliff-like exposures of Mahantango shale along the Delaware River south of Matamoras in northeastern Pennsylvania (Fig. 4) were steepened during the Late Wisconsinan glaciation (the last "ice age"). Thick deposits of rubble occur at the bases of these exposures, and glaciofluvial deposits sometimes interfinger with the rubble. Shale-chip rubble also accumulated in non-glaciated parts of Pennsylvania when ice age climatic extremes were present. During that time much of Pennsylvania was a grassy tundra, and mass-movement conditions common in periglacial climates could have stripped many slopes of all vegetation-supporting soil.

Exposed shale with numerous fractures (Fig. 2) is susceptible to disintegration even under present climatic conditions (debris at base of rock exposure in Figure 2 is modern accumulation), but increased freeze-thaw activity of periglacial climates would result in an increased rate of frost fracturing (congelifraction) of the shale, and increased production of shale fragments (congelifracts). Exactly how these fragments were transported and deposited is somewhat problematical.

Fragments derived from modern rock exposures proceed via rockfall to an accumulation at the base of the exposure or to intermediate accumulations created by irregularities in the rock exposure (Fig. 4). These fragment accumulations (called congelifractates when congelifraction is the primary mode of fragment production) are subject to further movement by sheet flow or mudflow, and the net result of this movement is to lower the slope angle of the deposit. Ancient shale-chip rubble deposits may have initially formed in the same manner.

Those shale-chip deposits which have whorls or prisms (Fig. 3) in their upper part have probably been subjected to permafrost (permantly frozen ground) conditions, and slow, flowage movement (solifluction) after their initial deposition. Such movement and distortion (congeliturbation) of initial uniform bedding occurs when very deeply frozen ground thaws near the surface and the thawed, water-saturated debris (congelifractate) moves slowly downslope. Some distortion of bedding, such as that shown in Figure 3, may result from expansion and contraction of ice without benefit of downslope movement.

The shale-chip rubble deposits of Pennsylvania were formed mainly during the Pleistocene. Those deposits along the Delaware River in northeastern Pennsylvania post-date Late Wisconsinan glaciation (deglaciation about 15,000 years ago), but precede established vegetation. Some deposits in Monroe County in northeastern Pennsylvania post-date Illinoian deglaciation (over 125,000 years ago), pre-date the subsequent Sangamon Interglacial, and show evidence of Sangamon weathering. Other rubble deposits in the area include Sangamon-weathered glacial deposits within their mass and thus were presumably formed during Wisconsinan glaciation. In one exposure in Carbon County in northeastern Pennsylvania a coarse-grained shale-chip rubble capped with a well-developed soil is overlain, above a sharp contact, by a fine-grained rubble. This sequence suggests two periods of development.

We must thus conclude that shale-chip rubble deposits in Pennsylvania formed at various times during the Pleistocene when climatic conditions favored accelerated frost fracturing and subsequent downslope movement and accumulation. Similar processes, except for solifluction, continue today, but not at such a rapid rate.

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TWO GEOLOGISTS JOIN SURVEY

WILLIAM B. BARBER

Bill joined the staff of the Bureau's Environmental Geology Division on November 8, 1979 as the environmental geologist assigned to western Pennsylvania. His office will be in Pittsburgh and his duties will include assisting individuals and planning agencies on matters dealing with geologic hazards, landslides and general information on the geologic environment.

In 1977 Bill graduated cum laude with a B.S. in geology from Kent State University. Immediately following, he started graduate studies at Kent. His course background dealt with environmental geology, engineering geology and hydrogeology. He was also involved in a variety of consulting work. This work included site evaluation for a prospective sand and gravel operation, housing developments, and detailed topographic mapping of drainage courses. His thesis "A geologic and geophysical survey of glacial drift in Streetsboro, Ohio" involved the use of seismic and electrical resistivity surveys, along with well data, to define bedrock topography and the nature of the glacial drift with respect to possible aquifers and sand and gravel deposits.

Upon acceptance of the Survey position, Bill moved his family to McMurray, PA in Washington County, from Ravenna, Ohio where he was born. Bill lives with his wife Mary Beth and son Justin.

Bill is a member of the National Water Well Association and the Pittsburgh Geological Society.

JAMES R. SHAULIS

James R. Shaulis, a native of Somerset County recently joined the Geologic Mapping Division of the Survey as a coal geologist. His responsibilities include areal appraisals of the bituminous coal resources and geologic mapping in western Pennsylvania. Jim received his B.S. degree in the geological sciences from the Pennsylvania State University in 1971. He has also done graduate work in paleontology and education at Penn State and has obtained teachers certification in earth science and biology from Skidmore College in 1976. Before coming to the Pennsylvania Survey Jim spent over two years working for Skelly and Loy Engineers in Harrisburg, as an exploration coal geologist primarily concerned with the design and supervision of coal reserve evaluation studies in both the bituminous and anthracite fields. In addition to this he also worked for over two years as a director/curator of the Pember Museum of Natural History in Granville, New York. His professional interests include the geology of southwestern Pennsylvania (especially the structure and stratigraphy of Chestnut Ridge anticline). At present as a side project, he is co-authoring, with Dr. Roger J. Cuffey of the Pennsylvania State University, an article entitled "Pennsylvanian Age jellyfish species *Wallcoti cairnbrooki*, the first jellyfish fossils found in Pennsylvania."

NATURAL GAS POLICY ACT (NGPA) PROJECT STARTS

The Bureau's Division of Oil and Gas Regulation started mailing information and forms relative to the Natural Gas Policy Act of 1978 (NGPA) on November 15, 1979. This Act was part of a total National Energy Plan signed into law by President Carter on November 9, 1978 with the effective date of December 1, 1978. The Federal Energy Regulatory Commission (FERC) was empowered to administer the Act by adopting rules and regulations consistent with the provisions of the Act. The Act provides a gradual move toward price deregulation by 1985 of newly discovered gas, with specified price increases for all categories of natural gas determined by well classification. It was necessary to obtain Pennsylvania legislative authority for a state agency to make well classifications as required by FERC. This authority was granted to the Department of Environmental Resources by Act 21, signed into law by Governor Thornburgh on June 28, 1979. Implementing the Act was assigned to the Bureau of Topographic and Geologic Survey's Division of Oil and Gas Regulation.

NGPA Staff—
Standing (left to right): C. Updegraff, R. Walther, F. Sturm.
Seated (left to right): B. Snowdon, B. Bell

The Bureau then prepared regulations based on the federal Act, detailing the procedures that Pennsylvania producers must follow to qualify for well classifications. These regulations were passed by the Environmental Quality Board on October 23, 1979, effective upon publication in the Pennsylvania Bulletin on November 3, 1979.

In the meantime, forms were being prepared and staff recruited to operate the program. Heading up the NGPA project is Charles Updegraff, who has been promoted from his former position of petroleum engineer to geologist supervisor. Joining Updegraff is geologist Richard Walther, who for many years has been an inspector with the Oil and Gas Regulation Division. Newly hired employes are geologist Frederic Sturm, who formerly worked for PennDOT and was a petroleum geologist in Montana, North Dakota and Oklahoma; and clerk typists Barbara Snowdon and Barbara Bell.

The function of the staff will be to process the applications by examining the data submitted by each applicant to justify the category for which he seeks a determination. The staff will be involved in reviewing classification requests for four major categories, "New Natural Gas," "New Onshore Production Well," "High Cost Gas," and "Stripper Well," three of which have several sub-categories. Each category has a different allowable maximum ceiling price set by federal law. It is the staff's obligation to assure that the data submitted with each application is sufficient to meet the federal criteria for the well classification that is requested by the applicant.

A backlog of approximately 4000 applications is on file with many more applications anticipated. A $30.00 filing fee to cover the state cost of administering the program, is required for each well determination application. In addition, a FERC form and Pennsylvania forms must be completed and submitted with geologic, engineering and production data to support the requested classification.

Additional information may be obtained by contacting Charles Updegraff at 412/565-5075 at the Bureau offices in Pittsburgh at 1205 Kossman Building.

PENNSYLVANIA OIL AND GAS FIELDS PROJECT

The Pennsylvania Geological Survey, Oil and Gas Geology Division, has been funded by the University of Oklahoma in Norman, Oklahoma, to revise, update, and standardize the oil and gas fields of Pennsylvania. The proposed two-year project, sponsored by the Department of Energy, involves three major tasks: (1) designation of the production reservoirs for each of the nearly 30,000 wells on record; (2) determination of the historical information concerning field and pool names, discovery dates, and boundaries; and (3) encoding this information into the University of Oklahoma's computer system. The project will eventually standardize the names and boundaries of Pennsylvania's fields. The Pennsylvania Geological Survey will complete the task by publishing a new oil and gas fields map that will show not only names and general production information (deep vs. shallow; oil vs. gas), but will also indicate boundaries and producing reservoirs for all fields. The project is scheduled for completion in June, 1981.

THE SURVEY AND PENNSYLVANIA TO MISS NATIONALLY KNOWN GEOLOGISTS

DR. JACOB FREEDMAN

The Pennsylvania Survey and the entire geologic community lost a good friend and outstanding scientist in the death of Dr. Jacob Freedman this past July. Dr. Freedman, past co-operating geologist with the Bureau of Topographic and Geologic Survey, past Chairman and one of the original members of Franklin and Marshall College's Geology Department, was a special friend to his students and colleagues alike. For those who knew "Jake," his smile and enthusiasm, his love of geology, and his concern for his fellow man will always be remembered.

Dr. Freedman's best-known work for the Pennsylvania Geological Survey involved the economic geology of the Mount Holly Springs area in Cumberland County. The high-quality white clays of the area, important to our mineral industry in the past, hold still another promise for the future.

In recent years Dr. Freedman's interests involved trace elements in rocks and their importance to human nutrition and health. He wrote and lectured on this topic extensively. In 1975-76, Dr. Freedman was President of the Society for Environmental Geochemistry and Health.

Dr. Freedman is survived by his widow, Bertha, a son David, and a daughter, Marsha.

HAROLD W. ARNDT

Harold W. Arndt, a long-time friend and associate of the geologic community, died November 8, 1979. Most recently, he had been the curator of the mineral collections at Bryn Mawr College, continuing an interest that had developed over the past 50 years. He collected minerals with just about every well-known mineralogist of his time, including Samuel Gordon, Harry Trudell, William Clay, Morrell Baldwin, and Edgar Wherry. But Harold's pursuits were not just confined to minerals. He was something of a botanist, specializing in ferns and orchids; he shared a curiosity, along with his late wife Clair, in bird study; and above all, he was a conservationist, objecting to unnecessary disturbances or destruction of the natural environment.

Harold Arndt was born in Mauch Chunk (Jim Thorpe) in 1892 and graduated from Phoenixville High School. He attended Lehigh University, studying mining engineering under Dr. Benjamin Miller. His studies were interrupted during World War I and, upon his return to the area, he worked as a design engineer for several major steel companies and was responsible for many bridges throughout the country. In 1958, he retired from Belmont Iron Works in Philadelphia.

Harold Arndt was an active participant in many societies and groups in southeastern Pennsylvania. He served as president and vice president to the Philadelphia Mineral Society in the late 40's and early 50's and as president (1953-1960) and treasurer (1960-1977) of the Delaware County Institute of Science in Media. Aside from capably handling the offices he held, Harold showed sincere concern for all who came for help and became a significant influence to several aspiring geologists and mineralogists. Always with a smile and a twinkle in his eyes, he was willing to give his time and his help. Because of failing health, he was unable to attend the last few annual Pennsylvania Field Conferences, but prior to that, he rarely missed one. We at the Pennsylvania Survey wish to acknowledge the dedicated service that Harold W. Arndt provided to the geologic profession.

SURVEY ANNOUNCEMENTS

REPORT ON PENNSYLVANIA'S OIL AND GAS

The Bureau of Topographic and Geologic Survey has published

"Oil and Gas Developments in Pennsylvania in 1978," the annual summary of production and exploration for oil and gas resources in the Commonwealth. Co-authored by Robert G. Piotrowski and the staff of the Survey's Oil and Gas Geology Division, the report highlights increased exploration activities for the year 1978.

During the year Pennsylvania's oil production rose 6% to 2,819,742 barrels from a total of 27,768 producing wells. Oil reserves at the end of the year declined slightly to 48,156,000 barrels, a sign that production exceeded the rate of discovery of new reserves.

Natural gas production in Pennsylvania in 1978 rose to 97,763 million cubic feet, 6% above the previous year. Most significantly, gas reserves still in the ground increased to 2,093,516 million cubic feet; this is up 11% from the prior year, a tribute to effective exploration.

The total number of new wells completed in the state in 1978 was 1748, a 20% increase over the prior year. Drilling for natural gas showed the greatest increase, with Indiana, Westmoreland, Clearfield, Erie and Jefferson Counties leading in gas development.

Progress Report 192, "Oil and Gas Developments in Pennsylvania in 1978," is available from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125. The price is $1.80 (plus tax for Pennsylvania residents).

GEOLOGY OF THE MONTOURSVILLE-MUNCY AREA

"Geology and Mineral Resources of the Montoursville South and Muncy Quadrangles," by senior staff geologist Dr. Rodger T. Faill has been published by the Pennsylvania Geological Survey. Complete with detailed maps of the bedrock geology and glacial deposits (1:24,000) and a comprehensive text, the report enumerates the complex geology and mineral resources which greatly affect and influence the development of this growth area adjoining Williamsport and straddling the Susquehanna River. The increasing demands for building materials, sites for suburban home and industrial development, and the needs for water resources and waste disposal, all require detailed information on the geology of the area.

This new report will benefit a wide range of users. The sections on economic resources and environmental geology provide cogent information for decisions by local officials, county planners, industries, and transportation designers.

Atlas 144ab, "Geology and Mineral Resources of the Montoursville South and Muncy Quadrangles" is available for $14.10 (plus tax for Pa. residents) from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125.

MONROE COUNTY GEOLOGY AND GROUNDWATER RESOURCES

A detailed report "Geology and Groundwater Resources of Monroe County, Pennsylvania" has been published by the Pennsylvania Geological Survey as Bulletin W 47. Authored by Louis D. Carswell and Orville B. Lloyd, Jr. of the U.S. Geological Survey, the 42-page report with its detailed geologic and hydrologic map, is the product of a cooperative project jointly sponsored by the U.S. Geological Survey and the Pennsylvania Geological Survey.

Monroe County includes much of the area popularly called the Poconos, a fast-growing region which is imposing increasing demands upon the geologic and groundwater resources of the area. The availability and quality of the water resources, particularly the largely underdeveloped subsurface water resources, is a key factor in planning for the future of this area.

Bulletin W 47, "Geology and Groundwater Resources of Monroe County, Pennsylvania," will serve the needs of property owners, planners, local officials, and business people, all of whom have a need to deal knowledgeably with the resources of the area. This report is available for $6.50 (plus tax for Pennsylvania residents) from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125.

GROUNDWATER IN THE DuBOIS AREA

Subsurface water availability and groundwater quality are particularly important to the DuBois area of Jefferson and Clearfield Counties where industrial development, population growth, and mining activities all impose special problems upon the water resources of the region. The Pennsylvania Geological Survey has published Water Resource Report 45, "Groundwater Resources of the DuBois Area, Clearfield and Jefferson Counties, Pennsylvania," by Evan T. Shuster. Two large detailed maps (scale 1:48,000) covering eight 7-1/2′ quadrangles show (1) groundwater yields and related features, and (2) depths to the water tables and to the top of the subsurface salt water of the area.

The maps, with accompanying texts, will be of benefit to all water users of the area, and particularly to local officials, planners, and developers who must be able to plan ahead for development in relation to water availability.

Water Resource Report 45, "Groundwater Resources of the DuBois Area, Clearfield and Jefferson Counties, Pennsylvania," is available from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125; the price is $5.50 (plus tax for Pennsylvania residents).

ENVIRONMENTAL GEOLOGY OF THE GREATER YORK AREA

A comprehensive atlas with detailed maps of major geologic factors has been compiled by J. Peter Wilshusen of the Pennsylvania Geological Survey and published as Environmental Geology Report 6, "Environmental Geology of the Greater York Area, York County, Pennsylvania." Covering an area from Thomasville on the west to Red Lion on the east, the plates include a geologic and mineral resources map, a groundwater availability map, and a map identifying the engineering characteristics of the rocks of the region.

This environmental geology atlas is the second major urban area environmental atlas produced by the Pennsylvania Survey (Greater Harrisburg Area was the first) specifically designed to identify and present the environmental geology characteristics of an expanding urban area in a format suited to the varied needs of the community. Local officials, planners, developers, industry, and individual property owners can all benefit from the information presented on the maps and accompanying texts.

"Environmental Geology of the Greater York Area, York County, Pennsylvania," EG 6, is available for $13.00 (plus tax for Pennsylvania residents) from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125.

GRAVEL RESOURCES IN NORTHWESTERN PENNSYLVANIA

Recognizing the declining availability of quality gravel resources in northwestern Pennsylvania, Dr. Jesse L. Craft has carried out field and laboratory studies designed to help locate additional supplies of gravel needed to meet the standards of the consuming industries of the region. The results of Dr. Craft's studies are detailed in the Pennsylvania Geological Survey's new Information Circular 86, "Quality of Ground Resources in Northwestern Pennsylvania." This 55-page report, with accompanying figures and tables, identifies the conditions and locations in the field which are most suitable for locating quality gravel resources in the study region.

The report will be of particular interest to land use planners and all who are concerned with various aspects of the construction industry, including highway engineers and industrial developers.

Information Circular 86 is available for $1.50 (plus tax for Pennsylvania residents) from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125.

GEOLOGY OF CENTRAL BERKS COUNTY

A comprehensive report, "Geology and Mineral Resources of the Temple and Fleetwood Quadrangles, Berks County, Pennsylvania" has been published by the Pennsylvania Geological Survey. Authored by veteran staff geologist David B. MacLachlan, Atlas 187ab includes a detailed geologic map, a tectonic map, and a map showing the environmental geology factors which influence land use of this area adjacent to the city of Reading. The accompanying text elaborates on the extremely complex structures and rock types of the Great Valley and Reading Prong provinces encompassed by the report. Economic mineral resources of the area are identified and evaluated in text and map.

This report is a major contribution to understanding the geologic record of one of the most difficult sections of Pennsylvania's geology. With its broad coverage of geologic interpretation and practical applications, the report will be of interest and use to geologists, as well as all who are concerned with land use planning, resource development, and construction design.

Atlas 187ab, "Geology and Mineral Resources of the Temple and Fleetwood Quadrangles" is available from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125. The price is $12.25 (plus tax for Pennsylvania residents).

DEVONIAN SHALE MAPS AND REPORT ARE NOW AVAILABLE

The Oil and Gas Geology Division of the Survey has available for distribution two new publications about the Devonian black shale studies in Pennsylvania. In addition to the eleven maps and cross sections announced in the June, 1979 issue of Pennsylvania Geology, we have a structure map of the Onondaga Group and a report on the Devonian shales and sandstones in Pennsylvania.

The Structure Contour Map on Top of the Middle Devonian Onondaga Group in Western and Northern Pennsylvania was published as Morgantown Energy Technology Center (METC) EGSP Series No. 12 at a scale of 1:250,000. The report, called Black Shale and Sandstone facies of the Devonian "Catskill" Clastic Wedge in the Subsurface of Western Pennsylvania, consists of a 40 page booklet and accompanying thirty-nine 1:1,000,000 scale maps. It was published as EGSP Series No. 13.

Both of these items are available free of charge from the Survey or from METC. Requests should be made to: Pennsylvania Geological Survey, Oil and Gas Geology Division, 1201 Kossman Building, Pittsburgh, PA 15222; or Morgantown Energy Technology Center, U.S. Department of Energy, Eastern Gas Shales Project, P.O. Box 880, Morgantown, WV 26505.

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GROUND-WATER LEVELS
FOR
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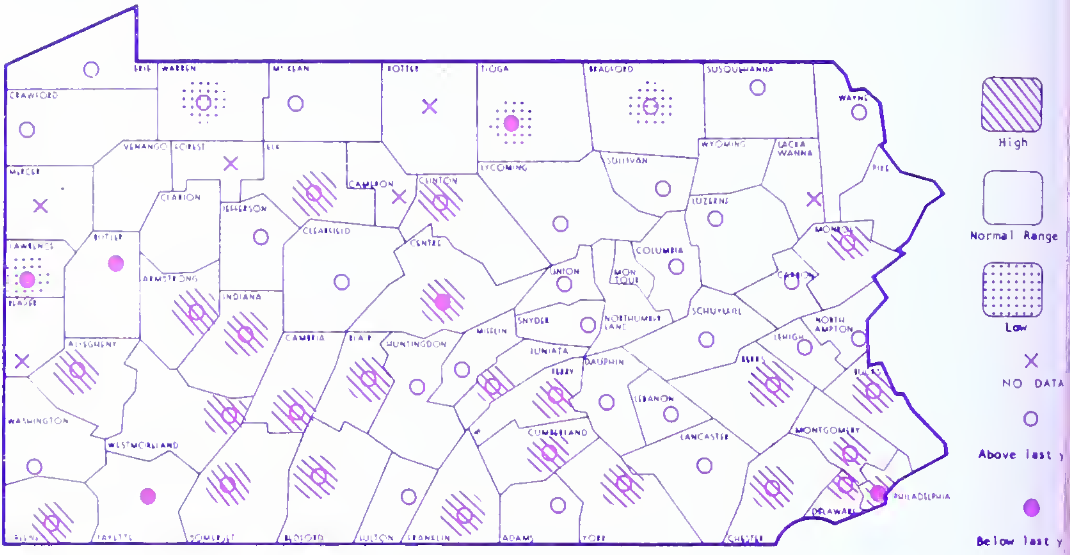

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THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 11/1

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: View of Allegheny River from Tidioute Overlook in Allegheny National Forest, Warren County. Photo courtesy of William H. Bolles.

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FEBRUARY 1980

FROM THE DESK OF THE STATE GEOLOGIST . . .

HOSTAGES – OUR PEOPLE, OUR ECONOMY

Hopefully, by the time this appears in print, the American hostages in the Mid-East will have been released, unharmed and in good health. While many complex events led up to this unfortunate episode, it is worth noting that a critical element of the background causes is the United States' dependence on Mid-East oil. And while our growing dependence on foreign oil imports has been highly publicized in recent years (we now import nearly 50% of the oil we use), the public is less aware that there is a growing list of other essential raw materials for which we are dependent on foreign sources. Included in this list for which we are more than 50% dependent on foreign sources are such industry essentials as bauxite (aluminum), chromium, cobalt, columbium, diamonds, manganese, mercury, mica, nickel, platinum, tin, tungsten, zinc, and potash. Many of these are coming to us from countries which are showing signs of internal instability, as well as from developing countries which are establishing their own industries and curtailing exports.

The taking of our fellow hostages has evoked feelings of anger, fear, and frustration among the citizens of this country. Being an economic hostage, based on our dependence for essential minerals from foreign countries, can only result eventually in similar reactions and drastic economic consequences. Any form of hostage is unpalatable and unacceptable. While the availability of critical mineral resources in the world is very unequal, it is vital to our self interest that this nation identify, make available, and develop its own mineral resources. This means locating deeply buried deposits, yet undiscovered; and it also means developing the expertise needed to extract and utilize our known low-grade mineral resources which are now considered uneconomic. The definition of uneconomic may also have to be reconsidered, for we cannot afford to be held economic hostage. With a long history of past mining and many indications of the presence of essential minerals, Pennsylvania mineral exploration and development should be stimualted as our contribution to avoid the untenable position of economic hostage.

Arthur A. Socolow

DEVONIAN SHALE GAS - A BONANZA IN THE BACK YARD?

John A. Harper

Every year the price of natural gas rises and many people have difficulties paying their monthly gas bills. For people in the Erie County area at least, there may be a solution—drill your own gas well in the Devonian shales. Erie County, and in particular the region along the lake shore, has been, and still is a leading producer of domestic gas in the state. A well drilled 500 to 1000 feet deep is likely to provide enough gas to meet most home owners' and some small business needs. In the past, however, most drilling attempted to find gas in the sandstone formations; now we are also focusing attention on the shale formations.

My optimism on this subject is the result of the U.S. Department of Energy's (DOE) multiyear program designed to stimulate interest and research in the hydrocarbon potential of the Devonian *shales*. The program, referred to as the Eastern Gas Shales Project, or EGSP for short, has brought numerous individuals, research groups, corporations, and government agencies (including the Pennsylvania Geological Survey) together to determine the factors which influence shale-gas distribution and development. Many agencies are busily attempting to develop stimulation techniques that will prove effective with the tight, massive shales. And as the research continues, some people are already taking advantage of the relatively shallow shale-gas.

Although the natural gas industry officially began about 100 years ago, the first reported well drilled specifically for natural gas was in Fredonia, Chautauqua County, New York, in 1821. The well was bored to a depth of 27 feet after gas was noticed seeping from a nearby creek bed. The gas was used for lighting and was said to have had the power of "two good candles." General Lafayette visited the town in 1825 and proclaimed the well one of the wonders of the world when it was lighted in his honor. In 1850 the well was deepened to 70 feet and produced enough gas to light 200 burners. In 1858 a second well was drilled over 200 feet deep and lasted another 30 to 35 years. What made these wells so interesting is the fact that they produced gas from the Devonian shales.

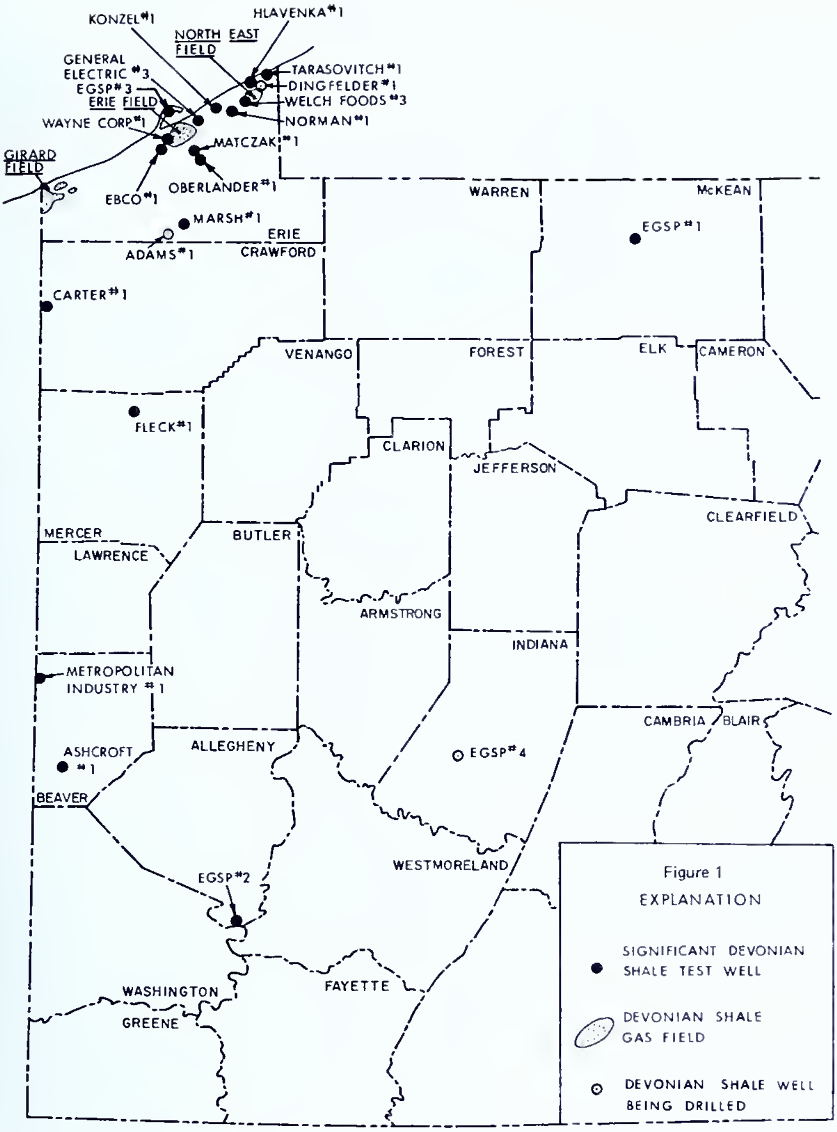

Figure 1

During the time of excitement following the Drake well discovery in 1859, Erie County became a target for oil drilling. Not much oil was encountered, but a great deal of natural gas was found and it soon became apparent that gas could be obtained in almost any well drilled to the proper depth. By 1890 more than 200 wells were known to have been drilled in the vicinity of Erie. Various reports by the existing Geological Survey of Pennsylvania include reference to wells drilled by industry, utilities, and small businesses. The Jarecki Manufacturing Company, the Erie Car Works, Stearne Manufacturing Company, the Erie Gas Company, the Erie Water Works, and Conrad's Brewery are among the many firms that had their own gas wells. Many of the companies partially or totally changed from coal to gas for their needs. The Jarecki Manufacturing Company, for example, was the first Erie firm to use gas from a well. The well, on an adjoining piece of property, was about 600 feet deep, and as the gas supply gradually dwindled the firm had a second well drilled on the plant site around 1868. This well initially supplied enough gas to light the plant and replace four tons of coal daily in the manufacturing process. Platt (1876) speculated that subsequent drilling in the area reduced both the rock pressure and the quantity of gas, because after seven years the well could only supply enough gas to partially light the plant. However, this may have been due to the normal production decline for shales, rather than overall gas depletion.

The Devonian shales continued to supply gas to industries and utilities, and even private homes and farms, throughout the 1800's and into the 1900's. Many wells drilled in backyards in the 1800's are, incredibly, still functioning, meeting the yearly gas requirements of the owners. The volumes and pressures may be low, but they are apparently enough to keep the home owners satisfied as well as warm during the winter. One home owner recently proudly claimed that during the severely cold winters of 1976 and 1977 he only had to have city gas supplied to his home for a total of five days. Otherwise he hasn't spent a penny for gas in the seventeen years he has lived in the house.

Since 1974, 16 shale-gas wells have been drilled in Pennsylvania and 3 others are being drilled at present (see Figure 1 for names and locations of these wells). This number is very small when compared to the thousands of gas wells drilled in the past six years into sandstone and limestone reservoirs. Most of the shale-gas wells are clustered in the Erie County area; this is because of the production history of the shales there, as well as the relatively shallow drilling depths of that area.

The Devonian shales can be divided into organic-rich, relatively radioactive, black shales and non-radioactive, gray shales and siltstones. Piotrowski and Harper (1979) have shown that the black shales can be divided into three major and three minor units in the subsurface of Pennsylvania. The major units, the Upper Devonian Dunkirk and Rhinestreet Shales and the Middle Devonian Marcellus Formation, have all been explored as natural gas reservoirs. The Dunkirk Shale and the associated gray shales and siltstones which overlie it are the reservoirs for most of the shale-gas production along the margin of Lake Erie (Figure 2). A probable natural fracture system in the shale along the margin of Lake Erie may constitute the

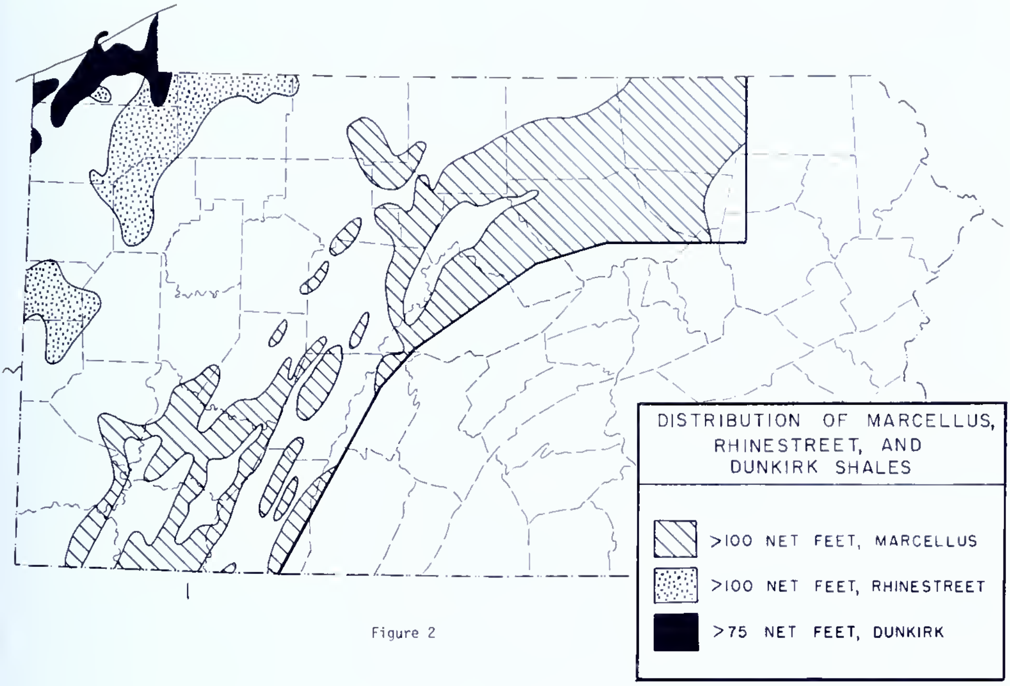
DISTRIBUTION OF MARCELLUS, RHINESTREET, AND DUNKIRK SHALES
▨ >100 NET FEET, MARCELLUS
░ >100 NET FEET, RHINESTREET
■ >75 NET FEET, DUNKIRK

Figure 2

most important part of this reservoir system. Further to the west, the Dunkirk thickens appreciably and becomes known as the Huron Member of the Ohio Shale of Ohio and Kentucky, areas where shale-gas have been produced in quantity for years. The Dunkirk gradually fades out to the southeast and disappears in Pennsylvania along a line from Beaver County to McKean County.

The Rhinestreet Shale and its associated gray shales and siltstones have been explored for gas only three times in Pennsylvania. One attempt, the Fleck well in Mercer County (Figure 1), ended in mechanical failure before completion of stimulation. The other two wells had production which rapidly blew down, probably because the impermeability of the shale prevented anything but a slow leak of gas into the fracture reservoir. The Rhinestreet Shale achieves its maximum development in Pennsylvania from Beaver to Warren Counties (Figure 2) and dies out along a line from Greene to Potter Counties.

The Marcellus Formation has been known for years to have gas in the black shales, but the shale-gas was ignored as a potential target until EGSP. Through DOE funding, three wells have been drilled to the Marcellus in Pennsylvania to test the gas in the Devonian shales and a fourth is currently being drilled (see Figure 1). EGSP #1 in McKean County was considered a lost hole by DOE because of hole problems. However, EGSP #2 in Allegheny County has been successful in obtaining gas from the Marcellus Shale, although the well is still being tested. EGSP #3 on Presque Isle in Erie County was also successful, but is producing gas from the Dunkirk and associated shales. EGSP #4 in Indiana County is presently being drilled. The Marcellus underlies all of western Pennsylvania, but it reaches its maximum development east of the Chestnut Ridge anticline in the central portion of the plateau (Figure 2).

Most of the shale-gas wells shown in Figure 1 are domestic wells; that is, they are used for private consumption. Most are wells drilled for the purpose of offsetting the rising cost of energy (for example, the Norman #1 well, reported on by Time Magazine in its March 27, 1978 issue). Piotrowski (1978) briefly reviewed the information available on the Welch Foods #3 well and the Erie Burial Case Company (EBCO) #1 well. The Welch Foods #3 well had a large initial flow of gas after stimulation, but the production rapidly dropped off. The well is currently shut-in because it is not considered economically feasible to lay a pipe line from the well to the plant. Piotrowski speculated that the rapid decline in production in the well may be due to depletion of the shale during the 1800's. The EBCO #1 well also had large initial volumes of gas, and as with the Welch Foods #3 well the volume declined. However, according to the plant manager the well is presently supplying enough gas to heat about 1/4 of the building, thus helping to reduce the company's fuel bills.

What makes the EBCO well important, besides proving that gas production from the Devonian shales is feasible, is that samples taken from the gas producing intervals were analyzed and shown to have significant amounts of expandable mixed-layered clay minerals in the shale composition. This phenomenon was first reported by Harper and Piotrowski (1978), and has since been corroborated from many of the Devonian black shales in the subsurface of Pennsylvania by the U.S. Geological Survey. If fresh water got into the well hole either by accident or during stimulation procedures, these expandable clays could cause swelling of the shales which in turn could decrease the flow of gas or even cause uncased portions of the hole to cave in. I suspect that these clays are the primary cause of shale-gas well failures in Pennsylvania where a foam-water fracture was used as the stimulation technique (e.g. Welch Foods #3, Metropolitan Industries #1, EGSP #1). The fact that the EBCO well was not stimulated may lend credence to this suspicion. Future shale-gas operations should be advised against the use of fresh water-based stimulation.

Although some of the problems involved with shale-gas exploration and production seem great, the benefits derived from a shallow shale-gas well would seem to more than offset them. Drilling a well several hundred feet deep could result in energy savings far outstripping the initial cost. The people living in Erie County are extremely lucky in this respect, because they live in an area where the shale-gas is known to occur at shallow depth. This means that a private gas well may be within the means of many home owners in the area. And that could mean a substantial long-term savings in energy costs. It's even better than insulation.

A word of caution: Drilling for natural gas should be done only by experienced gas well drillers and installers so as to insure the safety of the installation, as well as to protect and conserve the gas supply.

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Harper, J. A., and Piotrowski, R. G., 1978. *Stratigraphy, extent, gas production, and future gas potential of the Devonian organic-rich shales in Pennsylvania*: 2nd Eastern Gas Shales Symp., METC/SP-78/6, vol. 1, p. 310-329, Morgantown, WV.

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Platt, F., 1876. *Durability of the natural gas supply* in *Special report on the coke manufacture of the Youghiogheny River Valley in Fayette and Westmoreland Counties with geological notes of the coal and iron ore beds:* 2nd Geol. Survey of Pennsylvania, v. L, Appendix C, p. 161-172.

STUDENT QUIPS

from the bulletin
NATIONAL ASSOCIATION OF GEOLOGY TEACHERS
EASTERN SECTION, Fall, 1979 edition.

"I told Mr. Weinle (curator) that I had a semi-precious gemstone that was actually a shell." And he replied, "Abalone."

"Alexandrite the Great tried to conquer the world."

"Amethysts don't believe in God."

Survey Employees Retire

VIRGINIA MILEWSKI

On January 25, Virginia Milewski retired after working 21-1/2 years as a cartographic draftsman for the Survey. During that time, she built a record of outstanding workmanship in the preparation of camera-ready maps and illustrations for the Survey's various publications.

Virginia was born and raised in Mt. Carmel, Pennsylvania, and makes her home there. She joined the Survey in 1958 after working as a draftsman for the U.S. Geological Survey. Over the years, she became the Survey's resident expert on nutrition and health foods. Her other interests include music and gardening. Virginia's many years of competent and dedicated work, always done with a ready smile and cheerful attitude, has materially helped us to maintain the tradition of publishing high quality maps and reports. We extend our appreciation and gratitude to her on behalf of the Survey and the Commonwealth, and wish her a most successful, happy, and healthy retirement.

FLORENCE VEVERS

Mrs. Florence E. Vevers, retired on January 16, 1980 from the Bureau of Topographic and Geologic Survey, Division of Oil and Gas Regulation, where she served as the Division Secretary. Florence was in the Dept. of Mines and Minerals, now part of the Department of Environmental Resources, for sixteen and one-half years. Her first position was with the Deputy Secretary of Mines & Minerals,

W. Roy Cunningham, during the Scranton administration.

Mrs. Vevers has provided outstanding service to the Department and to the citizens of Pennsylvania, for which we are greatly indebted. We wish her long years of good health and happiness.

CLAY AND SHALE RESOURCES IN SOUTHWESTERN PENNSYLVANIA

A comprehensive report on the potential uses of clays and shales of southwestern Pennsylvania has been issued by the Pennsylvania Geological Survey. Designed to stimulate the ceramic industry and clay-shale production of the region, Mineral Resource Report 77, "Properties and Uses of Shales and Clays, Southwestern Pennsylvania" by Bernard J. O'Neill, Jr. and John H. Barnes, is a 689-page report, complete with detailed maps and tables. Southwestern Pennsylvania, as defined in this report, includes the following 12 counties: Allegheny, Armstrong, Beaver, Butler, Cambria, Fayette, Greene, Indiana, Lawrence, Somerset, Washington, and Westmoreland.

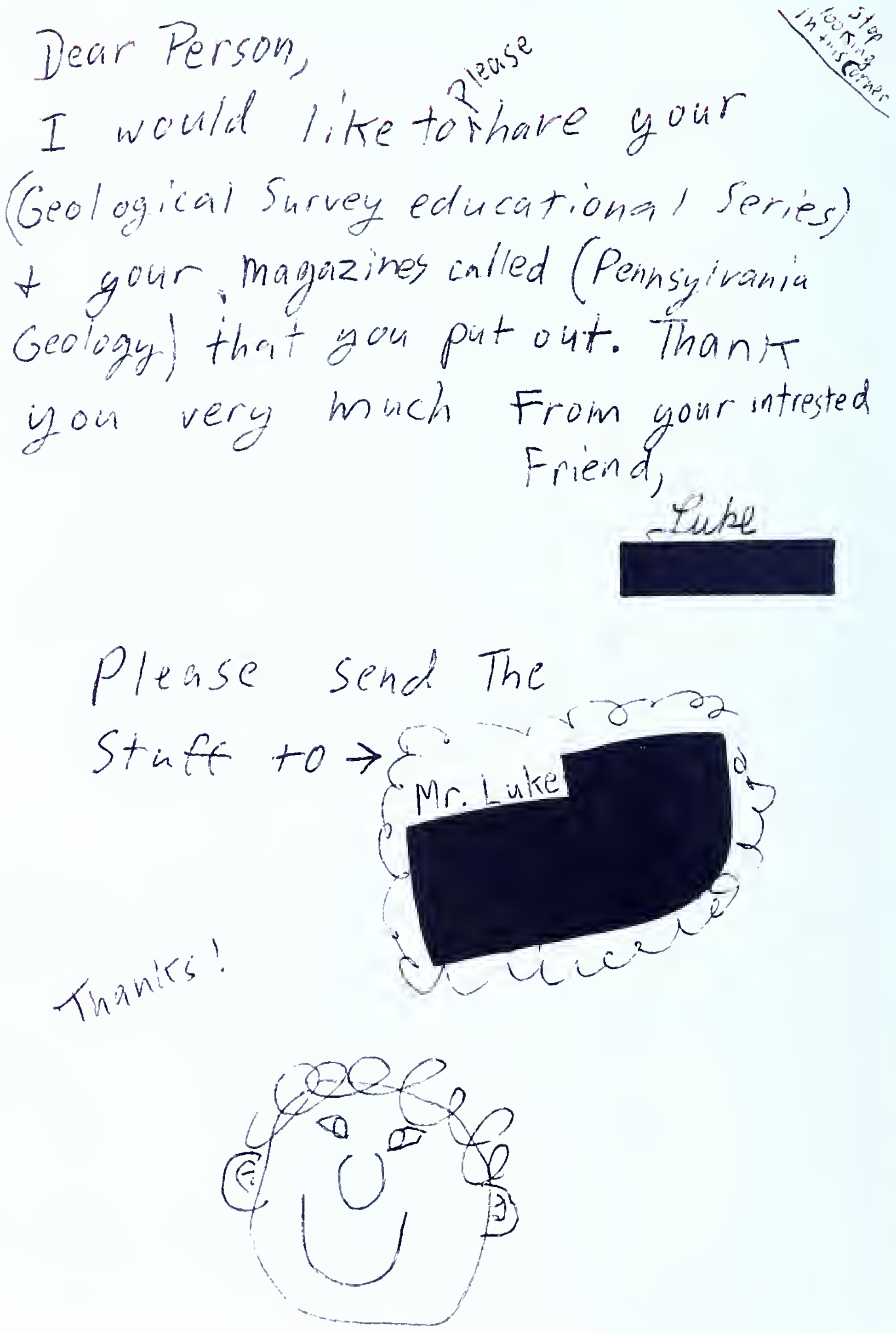
Data concerning physical, firing, chemical, and X-ray mineralogical determinative tests are reported for 413 clay-shale samples collected from 42 different stratigraphic intervals within 15 different geologic formations or groups. Preliminary evaluations indicate that 370 samples have a potential as a raw material for one or more of the following products: building brick, facing brick, floor brick, sewer pipe, drain tile, structural facing tile, nonload-bearing structural tile, lightweight aggregate, vitrified liner plates, and refractories.

The results of correlation studies are presented in order to determine what physical or chemical factors are responsible for favorable use results. Correlations were made employing the following variables: (1) stratigraphic interval and use; (2) mineralogy and use; and (3) chemistry and use. The stratigraphic intervals that correlate well with each use are identified, and the best exploration targets listed.

A geologic map showing the locations of the clay-shale sample sites and differentiating the different geologic formations or groups by color is included along with a generalized stratigraphic column for southwestern Pennsylvania.

Mineral Resource Report 77, "Properties and Uses of Shales and Clays, Southwestern Pennsylvania," may be purchased for $11.00 (plus 6% sales tax if mailed to a Pennsylvania address) from: The State Book Store, P. O. Box 1365, Harrisburg, PA 17125. Check should be made payable to Commonwealth of Pennsylvania.

FAN MAIL FROM OUR SCHOLARS



Stop looking in this corner

Dear Person,

I would like to please share your (Geological Survey educational Series) + your magazines called (Pennsylvania Geology) that you put out. Thank you very much From your intrested Friend,

Luke

[redacted]

Please send The Stuff to →

Mr. Luke [redacted]

Thanks!

Dear Sirs,

I am in High School and I must have this. Or I will have to sit in the rat Line so I worn you about this.

Would you please, please please send me a sample rock

This means so much to me if I get I will get an A on my report card I had so far 4 A's and 3 B's

So please send this to me

Or I could even sent in the corner if I dont get it Or you could send me A lot of Books on Rocks, Horses, Fossels

But please this means my life.

Thank you very much.

In the spirit of the Holiday season came this letter to us:

Pleays Send Me Pennsylvania

Thank you. Ho Ho Ho

In the interest of economy, we only sent a small piece.

York Mineral Show

The York Rock and Mineral Club will hold its Eleventh Annual Mineral and Gem Show on Saturday, April 5 and Sunday, April 6, 1980 at the Manchester Township Fire Company #1 in the Manchester Township Building, Emigsville, PA on Route 181 going north from York, PA.

Show hours are Saturday, April 5—10 AM to 6 PM. Admission will be $1.00—children under 12 free.

Survey Library Needs

The Pennsylvania Geological Survey Library is in need of the following book:

Stone, R. W. and Mohr, C. E., Caves of Pennsylvania. (National Speleological Society Bulletin vol. 15, 1953)

Please contact us if you have a copy to spare.

Correction

In the article "Ladder-back ripples in the Catskill Formation," Pennsylvania Geology, v. 10, no. 5, line 1 on page 10 should be line 1 on page 11, and vice versa.

hydrologic lab exercises

by John Tomikel, Professor
California State College of Pennsylvania

Hydrologic studies are becoming more important in the school science programs and elaborate discussions of the topic are beginning to become a part of modern textbooks. To tide instructors over until materials are more readily available this list of exercises has been created. This is an outline sketch of suggested activities. The instructor should write up each exercise with explicit directions. A general outline for the exercise format is 1) title, 2) suggested readings, 3) materials needed, 4) procedure, 5) questions to be answered, and 6) evaluation and conclusions.

Activities

1. Dig a cubic foot hole at 3 locations on a hillside, fill each with water and time the rate of percolation. Hand augers may be used for the same purpose as prescribed for on-lot sewage disposal systems. *Purpose: to determine percolation rates of different soils.*

2. Measure the discharge of a small stream by using simple weir and staff gauges for a three month period. A rain gauge can be set up near the weir to be read at the same time as the staff gauge. Perhaps the water level in a nearby well could also be measured. *Purpose: to correlate precipitation with discharge in a small area.*

3. Measure a pond for volume of water, surface area, evaporation rate on a particular day, and weight of water. Also if stream fed, measure the discharge. *Purpose: to convert volumes to weights and this can also be converted to hydroelectric potential.*

4. Get three large tubes, fill one with silt, one with sand, and one with gravel. Measure the rate of percolation through each of the materials. Tape a screen at the bottom open end to hold the sediments in. *Purpose: to illustrate the infiltration rates of different materials.*

5. Dig a hole and identify the soil water zones. Dig where the water table is near the surface. *Purpose: to become familiar with the nature of underground water.*

6. Draw a cross section which illustrates how ground water can occur under both water table and artesian conditions. *Purpose: to illustrate the movement of water in underground conditions.*

7. Based upon air and water temperature, flow rate, and geology attempt to identify the source of the water flowing from a spring. *Purpose: to give students on-site experience in obsering phenomena.*

8. Based upon indirect measurements attempt to estimate the flood-flow of a small stream after a flood. Describe the location and types of materials deposited by the flood. *Purpose: to determine the nature of flooding after a particular storm.*

9. On a topographic map outline a drainage basin and draw a topographic profile parallel to and across the main stem of the system. Describe the drainage pattern. *Purpose: to work with maps and identify stream factors from them.*

10. Visit a) sewage disposal plant, b) mine acid drainage settling basin, c) stream gauging station, d) stream locks and dam, e) multipurpose dam, f) city water treatment plant, g) agriculture conservation district office, h) rural water supply company.

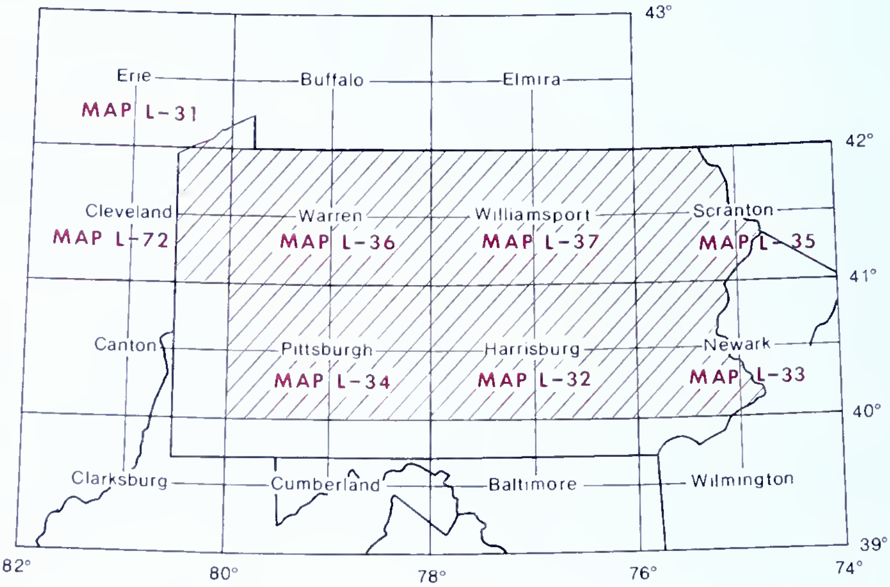
Dr. Tomikel will send a free copy of his article *Stream Sculpture Study*, which appeared in the *Journal of Geography* to anyone who writes to him and encloses a regular self-addressed stamped envelope with letter postage. Write: Department of Earth Sciences, California State College, California, Pennsylvania 15419.

LAND USE AND LAND COVER MAPS PUBLISHED

Prepared in cooperation with the Pennsylvania Department of Environmental Resources, a new Land Use Series of maps has recently been published by the U.S. Geological Survey. Pennsylvania was one of the first states in the Nation to have a complete land use survey using sophisticated new techniques devised by the U.S. Geological Survey. Utilizing the latest photo imagery available from high altitude planes, the land use and land cover maps recognize and delineate as many as 37 separate land use categories, some for areas as small as 10 acres. The scale of the published maps is 1:250,000 or approximately one inch on the map equalling four miles on the ground. Highway-type base material is printed in green with the land use and land cover information printed in black over the base.

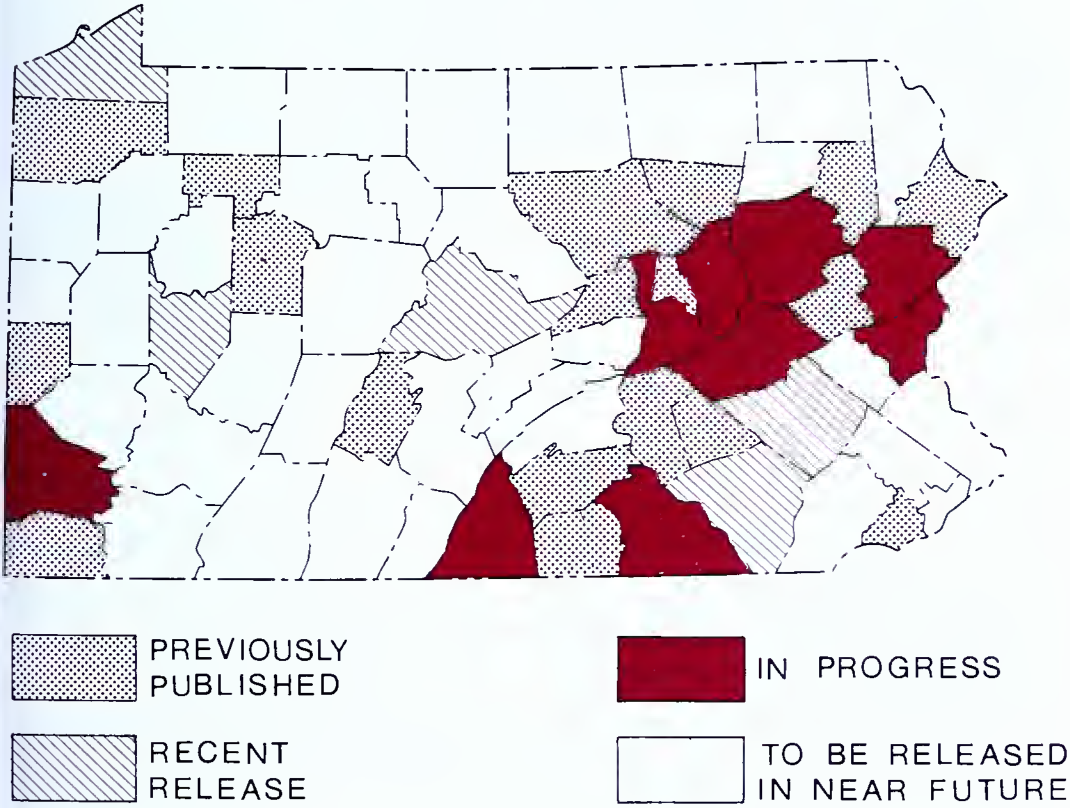
These land use and land cover maps are a valuable tool for anyone involved in comprehensive land-use planning. The maps and data should be of particular benefit to state and local government agencies, planners, industry, conservation groups and recreation agencies.

These new land use maps may be seen on file at the Pennsylvania Geological Survey, or may be purchased at $1.25 each from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, VA 22202. The accompanying diagram shows the name and number of each map available.



U.S. GEOLOGICAL SURVEY COUNTY TOPOGRAPHIC MAPS

During the past year five new county topographic maps have been published by the U.S. Geologic Survey. These include Armstrong, Berks, Centre, Erie and Lancaster counties. The maps are at a scale of 1:50,000 (approximately 400 feet to the inch) and follow the previously issued maps of Adams, Beaver, Blair, Carbon, Crawford, Cumberland, Dauphin, Delaware, Forest, Greene, Jefferson, Lackawanna, Lebanon, Lycoming, Montour, Pike, Sullivan and Union counties. These maps are multicolored, following the standard colors of topographic maps, with the addition of political boundaries for county, township and boroughs outlined in orange. These county maps are of widespread use to all who are concerned with county and regional planning, engineering, agriculture, and recreational projects. These maps may be obtained for $2.00 each by writing to Distribution Section, U.S. Geological Survey, 1200 S. Eads Street, Arlington, Virginia 22202.



MEET THE STAFF...

John A. Ifft, Chief
Division of Oil and Gas Regulation

John A. Ifft joined the Department of Environmental Resources as an Oil and Gas Inspector in 1972. At that time his duties were to maintain compliance with Pennsylvania Oil and Gas Laws within a 17 county district in southern Pennsylvania. He joined the Pennsylvania Geologic Survey in April 1979 when the Oil and Gas Division of the Bureau of Land Protection was transferred to the Survey as the "Division of Oil & Gas Regulation." On May 24, 1979 he was promoted to Chief of the Division.

The Division of Oil and Gas Regulation administers several different laws affecting the oil and gas industry. Act 225 provides for permitting of oil and gas wells, the underground storage of gas, mining around wells, and the methods of casing and/or plugging oil and gas wells. Act 359, the Oil and Gas Conservation Law, pertains only to the deeper producing horizons, and provides for the spacing of oil and gas wells, unitization of interests, and the protection of the correlative rights of oil and gas owners. Act 38 relates to the underground storage of gas and the protection of the people residing in the area.

John Ifft was born in Canton, Ohio and spent his early years in the western Pennsylvania oil fields. A veteran of the Korean conflict, he served in the U.S. Army in Korea in 1953-54. John obtained his B.S. degree in Geology and Mineralogy from the Pennsylvania State University in 1960. Prior to joining D.E.R. he owned and operated an oil and gas well contract drilling business in north-western Pennsylvania. He is a member of the American Association of Petroleum Geologists and of the Pittsburgh Chapter of the Society of Petroleum Engineers (SPE-AIME).

John, his wife Judy and their three children live in Washington, Pa. In the summer they can usually be found on weekends in their camp at Henry's Bend on the Allegheny River just north of Oil City.

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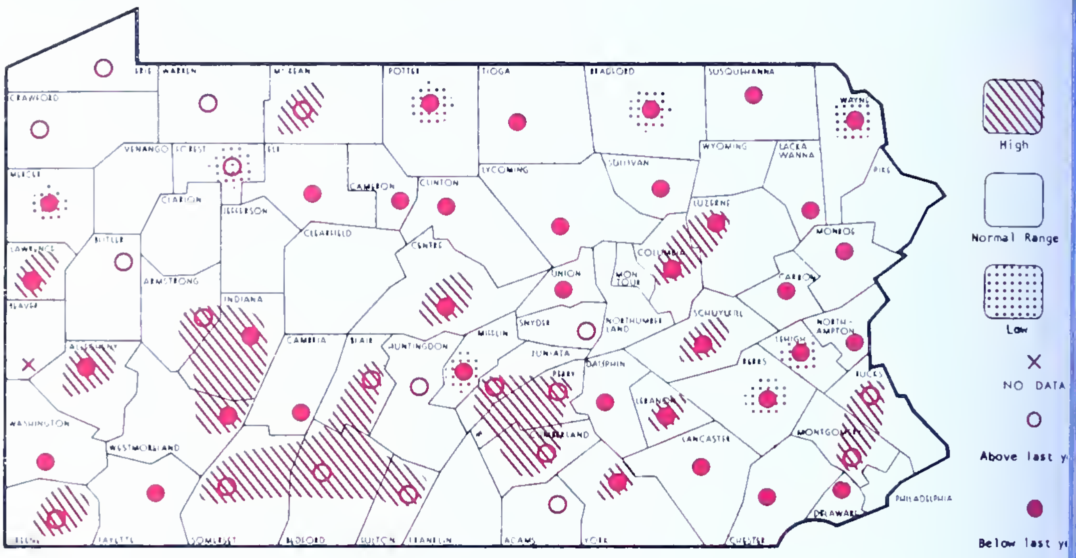
In Cooperation with The U.S. Geological Survey

GROUND-WATER LEVELS
FOR
JANUARY 1980



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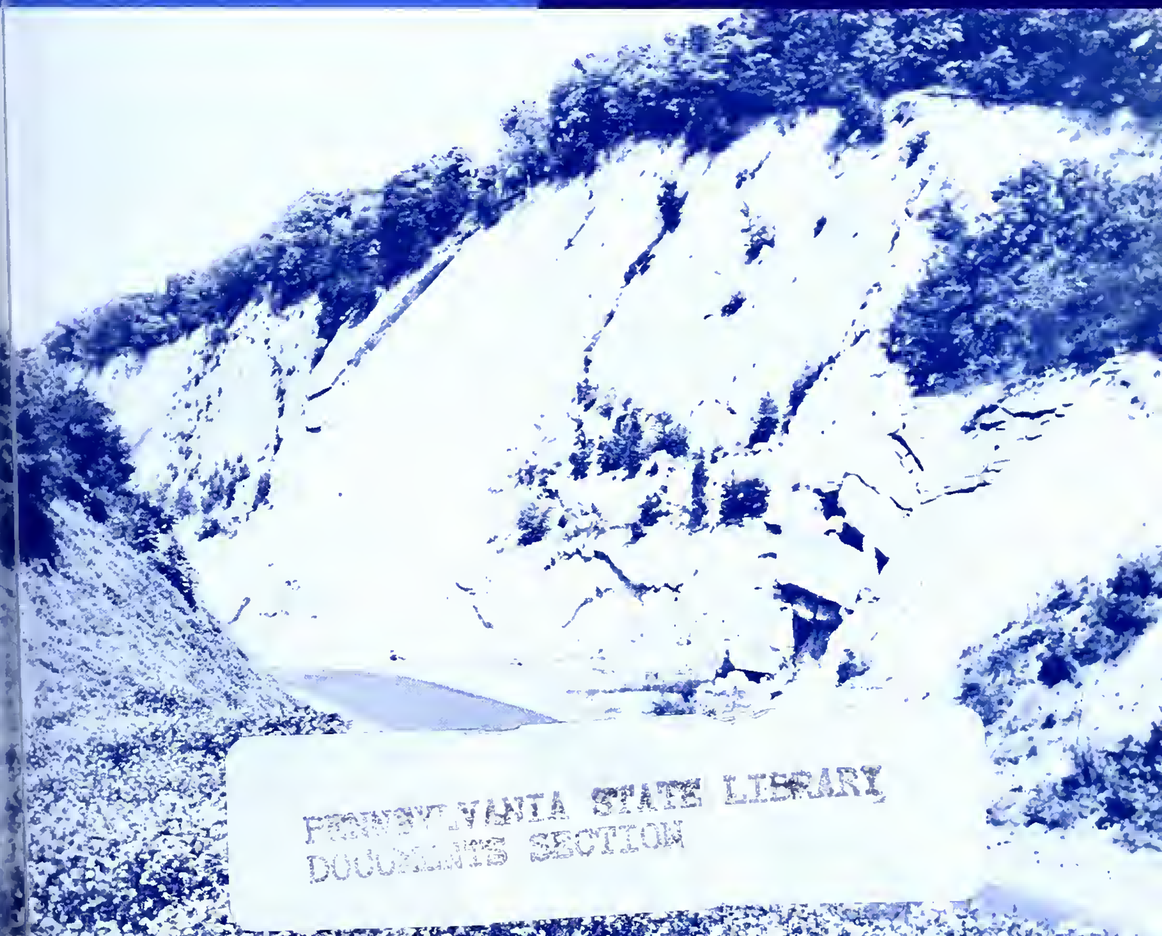
PENNSYLVANIA GEOLOGY



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THE PENNSYLVANIA GEOLOGICAL SURVEY [illegible]

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: View of entrance to a quarry in the Oriskany Formation near Mapleton, Pa. (Huntingdon County). This pure silica sandstone is a highly desirable raw material for the manufacture of glass. Photo courtesy of Commonwealth Photographic Services, Pa. Dept. of Transportation.

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Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

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APRIL 1980

FROM THE DESK
OF THE
STATE GEOLOGIST . . .

EVERY PLACE IS SOMEBODY'S BACKYARD

It was most appropriate that the 1980 meeting of the Pennsylvania Environmental Council focused on the theme "Hazardous Wastes: Everybody's Worry." Pennsylvania, and particularly DER, has in recent years become acutely aware that there is a serious problem with certain industrial and municipal wastes that must be resolved in the near future in order to safeguard the health of present and future generations. The recent illegal dumping of toxic liquids into anthracite mine voids, with subsequent pollution of the Susquehanna River, was the latest, well publicized such event in Pennsylvania. And of course, the Love Canal situation of upper New York is another highly publicized pollution situation. But the problem is not one of isolated occurrences; on one scale or another it is part of our daily industrial and municipal activities. Included in this list must be the problem of large-scale sewage sludge disposal with its heavy metals content; the federal government has set a date when ocean dumping must cease.

While Pennsylvania is properly moving with new legislation on the subject, the basic challenge is to find a solution to the problem. Wastes are endemic to the life process itself. It is excess waste which poses the first hazard and it is manufactured wastes which natural processes are incapable of neutralizing that result in the greatest hazards to man and the environment.

While in recent years much attention has been focused on the issue of high-level nuclear waste disposal, in terms of daily volumes created, geographical extent of the problem, and numbers of people affected, the disposal of non-nuclear hazardous wastes is by far the most extensive and challenging environmental problem facing our society.

The serious investigations and research which have been initiated on this subject invariably focus quickly on the fact that geology must and will play a major role in alternative solutions for hazardous waste disposal. This calls for accurate data on the location and characteristics of our rock formations, both on the surface and in depth. There are not only opportunities, but urgent need for sophisticated research into the physical and chemical characteristics of the various rock types.

While some of the wastes may be neutralized by industrial or chemical processing, there will be a major need for acceptable disposal sites where the conditions will eliminate or minimize the hazards to man. Geologists must help find those sites. We recognize that the final choices will involve other factors in addition to geology, but the responsibility for geologists is a major one.

As we noted at the PEC Conference, no one wants the wastes in their backyard. But everyplace is somebody's backyard. Geologists can help point to the safest ones.

Arthur A. Socolow

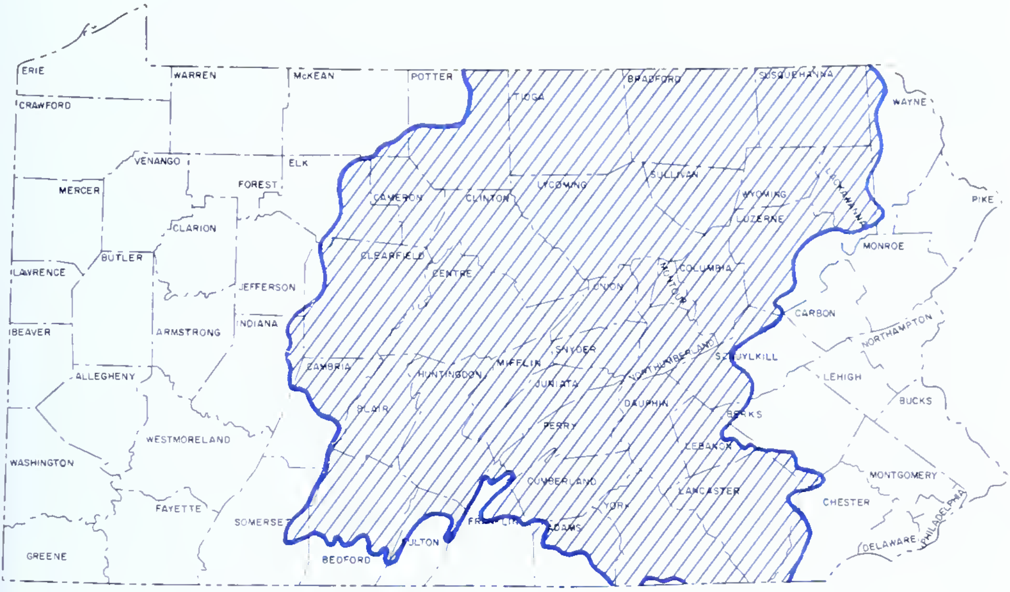
SURVEY TO PARTICIPATE IN MAJOR GROUNDWATER STUDY

The Pennsylvania Geological Survey and the Susquehanna River Basin Commission (SRBC) have begun a jointly funded groundwater study of the Pennsylvania portion of the Susquehanna River Basin. The project leader of the study is Larry Taylor, senior groundwater geologist of the Pennsylvania Survey. He is assisted by three SRBC geologists who have been employed specifically for this project. The study, a three-year project, is headquartered in the Survey offices in Harrisburg.

An important objective of the project is the collection and assimilation of the large amount of data and information that is needed to plan for the proper utilization and management of groundwater resources of the basin. The collected information will be used to prepare a series of reports to be published by the SRBC. The occurrence and availability of groundwater as related to geology, topography, and climate in addition to the natural or existing water quality of each aquifer or aquifer system will be described in the reports. The Pennsylvania Geological Survey will also utilize the data to prepare a series of groundwater summary reports for use by county and local officials, planners, and developers.

This project is part of a larger, four-year study of groundwater in the Susquehanna River Basin. Agencies from the states of Maryland, New York, Pennsylvania and the United States Geological Survey are cooperating with the SRBC in this effort. Several types of projects are planned including modeling of groundwater in high groundwater-use areas, concentrated evaluations of areas having the potential for the development of large quantities of groundwater for use in water supply or low flow augmentation, and large scale resource summaries for the primarily rural parts of the basin.

Additional information about the project may be obtained from Jerrald Hollowell of the SRBC, the study manager, or Larry Taylor at the Survey.



Susquehanna River Basin in Pennsylvania

CONTROL OF LAKE ERIE LEVEL BEING STUDIED

by John H. Barnes

Seven years ago, an article in *Pennsylvania Geology* reported on record high levels that were reached by Lake Erie (Barnes, 1973). An all-time record high lake level was reached in June of 1973, 2.5 feet above the normal June level of the lake. A decline in lake level began at that time, as the annual cycle of lake levels usually reaches a maximum in June. Monthly records continued to be broken, however, until November, when the lake was below the record-setting level it had reached the previous November. However, over the past seven years, the lake has still not reached its normal level. As of November 1979, it is 1.4 feet above the normal level for the month, and only 0.7 feet below the record for the month (Fig. 1).

There are essentially three types of variations noted in the level of Lake Erie. Short-term variations, often lasting hours or, at most, days, are the result of storms producing sustained high winds that

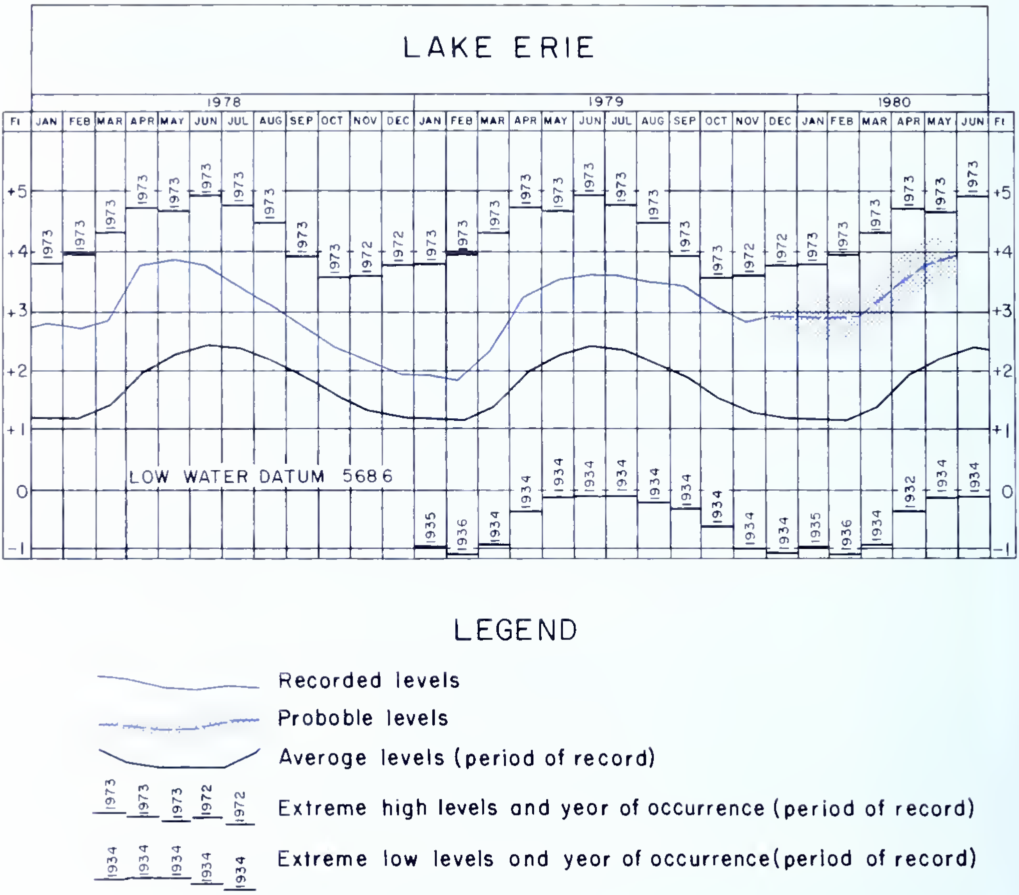


Figure 1

effectively tilt the lake level, producing low water at the windward end of the lake and high water at the leeward end.

Annual variations in the lake level are somewhat predictable (see Fig. 1) and generally follow a cycle with a maximum in June and a minimum in February, reflecting seasonal variations in precipitation and runoff.

Long-term variations are irregular and less predictable. The current high-water trend, which began in the late 1960's and reached its peak in 1973, was preceded by a period of low water in the early 1960's. Factors that influence these trends are variations in precipitation on the drainage basin, evaporation, and the inflow and outflow of the lake.

Extremely high or low lake levels can have serious consequences for those who use or reside near the lake. Water levels that are too high can result in increased occurrence of storm-related floods in low-lying areas, and accelerated erosion of shoreline property (Fig. 2). Levels that are too low can reduce hydroelectric power generation capacity and interfere with navigation and commerce by not allowing ships to be loaded to capacity.

Because of the seriousness of these problems, the International Joint Commission, a bilateral commission of Canada and the United States responsible for overseeing boundary waters issues, is currently studying the possibility of partial regulation of Lake Erie water levels. The study is considering only the reduction of long-term high water levels, such as has been experienced through most of the 1970's. Such reduction would be accomplished through some form of channel enlargement with a related control structure at Buffalo to increase the outflow from Lake Erie into the Niagara River. Depending on the alternatives found feasible, the outflow could be increased as much as 30,000 cubic feet per second. A preliminary study has shown that this increase in capacity could have reduced the maximum level of 1973 by 1.3 feet.

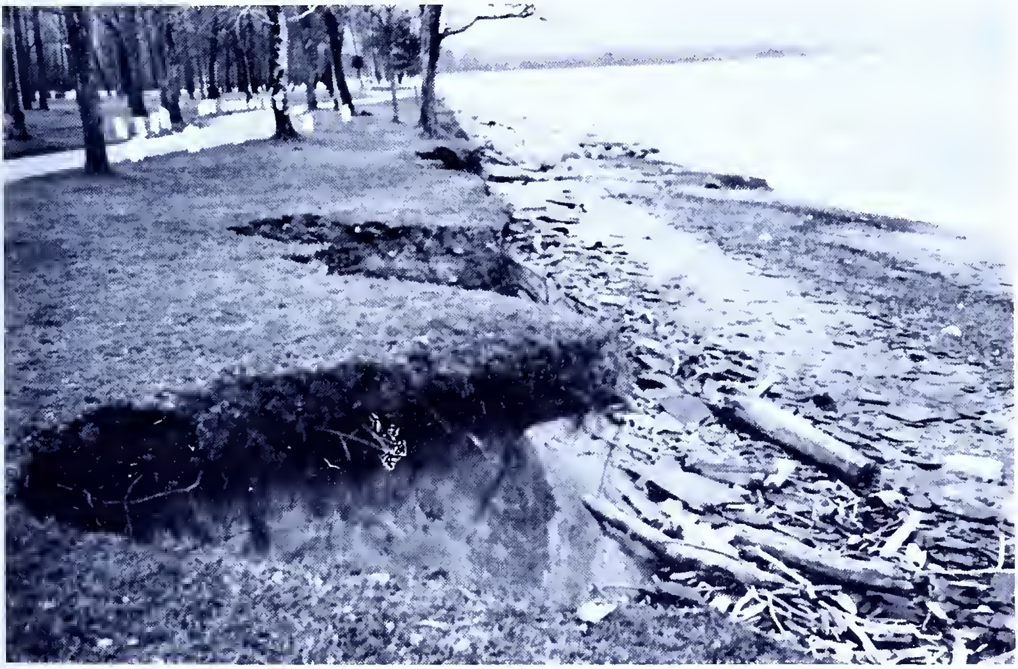


Figure 2. Erosion of unconsolidated material along the Lake Erie shore. The large semi-circular gaps are places where trees were undermined by erosion and fell to the beach below.

The study is concerned with methods of regulation, economic feasibility, and effects on power generation, navigation, shoreline erosion and flooding, and environmental effects. Consideration must also be given to the effects on water levels in Lake Ontario and the St. Lawrence River.

The study is seeking public response to the proposals, and will be issuing newsletters on the subject in the spring and summer of 1980. For additional information, or to comment, write to Public Affairs Office, U.S. Corps of Engineers, Buffalo District, 1776 Niagara Street, Buffalo, NY 14202.

REFERENCES

Barnes, J. H. (1973) *Lake Erie reaches record high level*, Pa. Geology, v. 4, n. 3, p. 2-4.

International Lake Erie Regulation Study Board (1979), *Lake Erie Water level study*, Newsletter No. 1, Fall 1979.

DEVONIAN ORISKANY SANDSTONE PROJECT ON OPEN FILE

A regional study of the Oriskany Sandstone in the Subsurface of Pennsylvania by Kathleen D. Abel and Louis Heyman was completed this year and is scheduled for publication in late 1980. The study is based on gamma ray log correlations of all available wells in Pennsylvania that penetrate the Oriskany.

The following maps at a scale of 1:1,000,000 are the final products of the Oriskany project:

1) Ridgeley isopach and sub-Onodaga subcrop map
2) Sandstone thickness map
3) Oriskany production map
4) Drilling depth map (shows depth to top of Oriskany)

LOWER SILURIAN MEDINA SANDSTONE PROJECT ON OPEN FILE

The Lower Silurian Medina Sandstone Group is one of the most actively drilled targets for natural gas in Pennsylvania. In 1979, 128 gas wells were successfully completed in Erie County along in this horizon.

Prepared as part of the project are a series of nine regional cross sections defining the regional stratigraphy of the Lower Silurian clastics in Northwestern Pennsylvania. Also included are a series of eleven maps detailing gas production, drilling depth, structure on top of Queenston, a series of isopach maps plus net sand isolith and sand/shale ration of the Medina Group.

Both of these reports are now available for inspection prior to publication at the Pennsylvania Geological Survey, Oil and Gas Geology Division, 1201 Kossman Building, Pittsburgh, PA 15222.

NEW USGS PENNSYLVANIA WATER RESOURCES CHIEF

David E. Click has been named the U.S. Geological Survey's top water-resources official in Pennsylvania, and will direct the USGS cooperative water-investigations and data-management program in the state.

A 20-year veteran with the USGS, Click comes to the Pennsylvania post after serving 2 years as chief of the USGS Water Resources Division's Ohio program. He succeeds Norman H. Beamer, who retired after 32 years with the Survey.

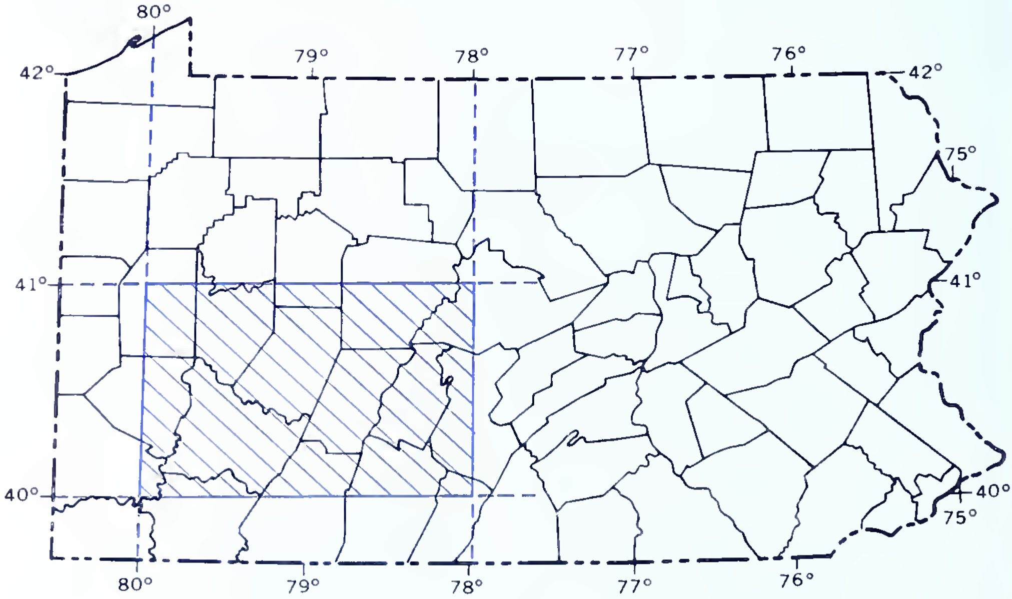
Click directs a staff of more than 100 hydrologists, technicians, and administrative personnel. He administers the USGS water-resources program in cooperation with other federal, state, and local agencies to measure and assess the quantity and quality of the state's surface-water and ground-water resources and to conduct flood and other special interest water studies. The USGS state program operates from headquarters in the Federal Building in Harrisburg, with subdistrict offices in Pittsburgh, Harrisburg, and Malvern, and field offices in Williamsport and Meadville.

The office of David Click also serves as a public liaison for all branches of the U.S. Geological Survey. Should anyone have any matters they wish to direct to the USGS, Dave Click's office can be of service. The address is: David E. Click, Water Resources Division, U.S. Geological Survey, P.O. Box 1107, 4th Floor, Federal Building, 228 Walnut Street, Harrisburg, Pa. 17108.

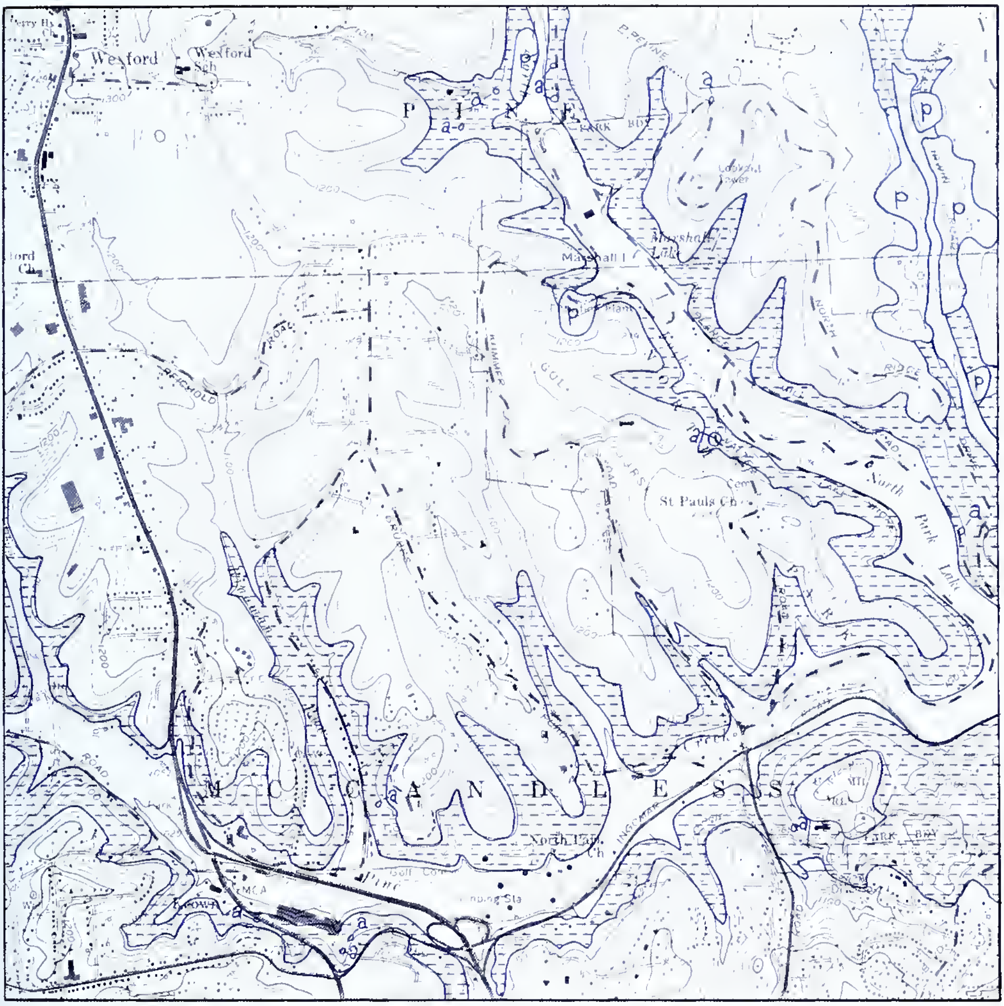
LANDSLIDE MAPS ON OPEN FILE

Maps of landslides and related features in an area covering all of Blair, Cambria, Indiana and Westmoreland counties and portions of Allegheny, Armstrong, Bedford, Butler, Centre, Clarion, Clearfield, Fayette, Fulton, Huntingdon, Jefferson, Somerset, and Washington counties, as shown on the index map below, have been released by the U.S. Geological Survey and are on open file at the office of the Pennsylvania Geological Survey. The maps consist of 128 quadrangles (7½-minute series, 1:24,000 scale) which by different symbols show active or recently active landslides, old landslides, slopes that are susceptible to sliding, slopes with small landslides, areas susceptible to debris flows and debris avalanches, areas susceptible to rockfall, and areas least prone to landslides. The maps were prepared by John S. Pomeroy and William E. Davies of the U.S. Geological Survey.

Depositories for the maps are the U.S. Geological Survey Library, Reston, Virginia and the Pennsylvania Bureau of Topographic and Geologic Survey, 914 Executive House, Second and Chestnut Streets, Harrisburg. The maps will be available for review and inspection at the Bureau offices in Harrisburg and may be copied from mylar originals at the user's expense.



Location of open file maps



EXPLANATION

ⓟ	Landslide. Area of extensive hummocky ground caused by earthflow and earth and rock slump
srg	Reclaimed by grading
┬┬┬┬	Areas susceptible to rockfall Steep, locally vertical, natural and man-made slopes and cliffs.
- - -	Soil and rock susceptible to landsliding
ⓐ	Active or recently active landslide

Example of landslide mapping from open file map. Not all of the map symbols are shown in this example.

New Survey Report Provides Key To Crawford County Drainage Puzzle

Samuel S. Harrison
Allegheny College

The report on the Geology and Groundwater Resources of Western Crawford County, recently published by the Pennsylvania Topographic and Geologic Survey, provides information from which the location of ancient stream paths can be determined. The basic data in the report, painstakingly compiled by U.S.G.S. geologists George Shiner and Jack Gallaher, includes a map showing the thickness of glacial drift. The areas shown to have more than 100 ft. of drift over bedrock are most likely valleys which existed prior to the end of the Wisconsin glaciation. (Fig. 1).

Some of the NW-SE running valleys in western Crawford County contain in excess of 500′ of natural, glacial fill. These filled valleys were the main drainageways in pre-glacial time. Some, such as Cussewago and portions of French Creek, still contain sizeable streams. Others presently carry little surface water (e.g. Conneaut Marsh), and still others are not presently the site of streams. These latter are true buried valleys, giving no hint to their presence except through careful examination of water well records. The drift-thickness map in the new report makes possible the identification of several buried valleys for the first time.

The new report solves an important mystery of local drainage which was pointed out by Leverett in 1902. Leverett noted that the portion of the French Creek channel near Saegertown is within several feet of bedrock, whereas upstream (near Cambridge Springs) and downstream (near Meadville) valley fill exceeds several hundred feet. That there had to be a buried valley which was the connecting link between these two ancestral reaches was evident. Examination of Schiner and Gallaher's drift thickness map now reveals that the mysterious French Creek connection is buried beneath what is now an upland area north of Saegertown. Wells here show over 250′ of drift whereas bedrock is usually encountered at 10′-20′ depths in the uplands. French Creek now flows in a channel which is within a few feet of bedrock and located only a few thousand feet east of

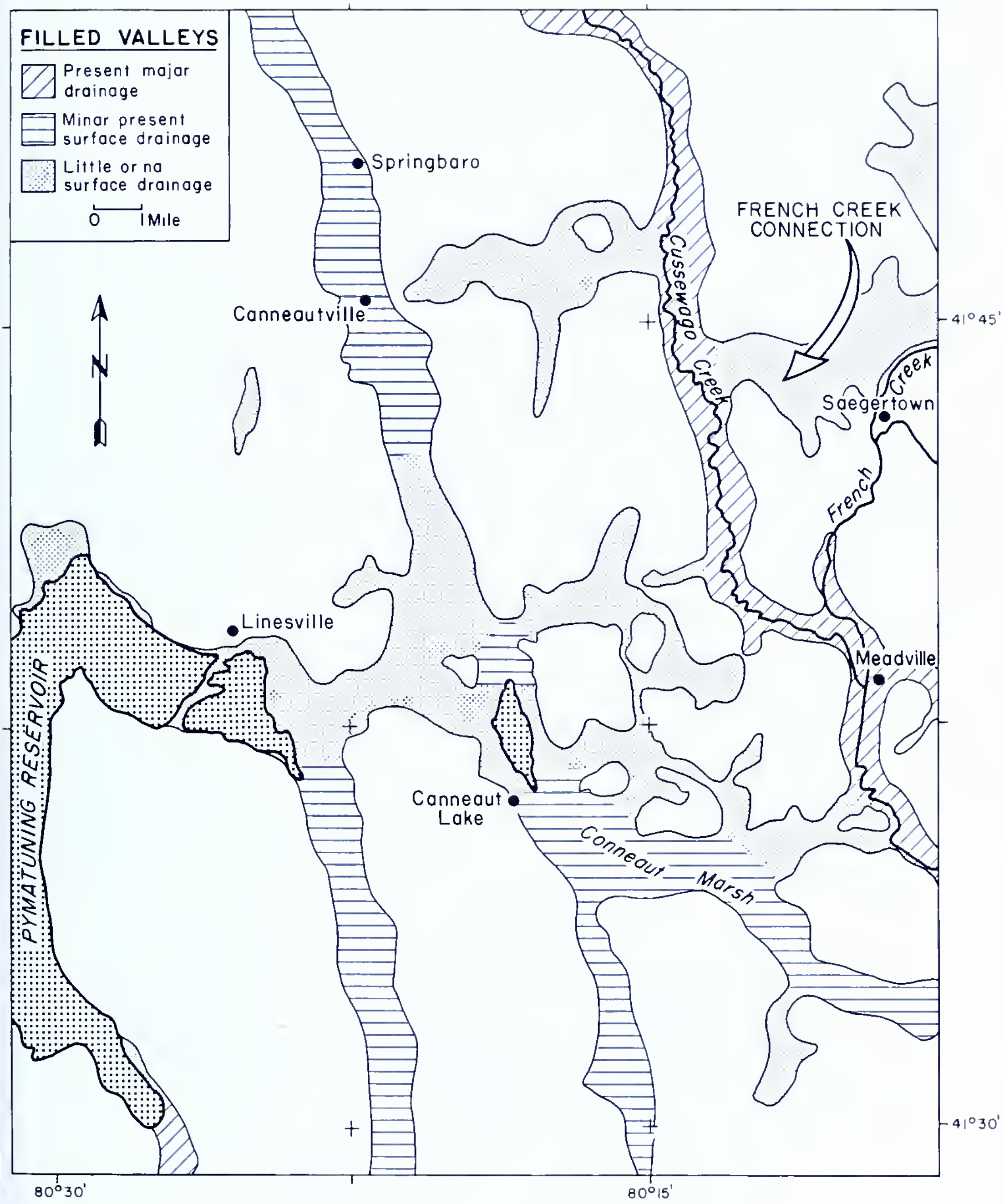


Figure 1. Areas in Western Crawford County where drift is more than 100′ thick (from Schiner and Gallaher, 1979). Previously unlocated French Creek connection shows that the juncture of French and Cussewago creeks was once six miles WNW of its present location.

this buried valley connection. It is now apparent that former juncture of French and Cussewago Creeks was some six miles WNW of its present location.

Smaller buried and filled valleys which are tributary to the main ancestral NW-SE valleys are also indicated by the study. One such buried tributary valley became evident after several water wells drilled in a new housing development showed that Pennsylvania sandstone "bedrock," encountered only a few feet below the surface, was underlain by 100'+ of glacial drift. Detailed study showed that a slab of bedrock 2¼ acres in extent had been quarried by the glacier, transported *en masse* for nearly one mile, and deposited near the top of this valley fill sequence (Topp and Harrison, 1975).

It appears from the map (Fig. 1) that preglacial valleys which had an orientation roughly parallel to the direction of ice flow (NW-SE) were not completely filled, but remain as present-day surface drainageways. Those preglacial valley reaches which were oriented perpendicular to the ice flow, however, appear to have been completely filled in. They are now buried valleys which carry little if any surface drainage.

Besides providing important clues for those interested in deciphering earlier drainage systems in western Crawford County, the Water Resources Report 46 also has very practical implications for future land use. In many places the sediment sequences in these filled and buried valleys provide excellent aquifers. Large industrial water wells in these valleys yield as much as 2,000 gpm whereas very few bedrock wells in the area yield more than 100 gpm.

REFERENCES CITED

Leverett, Frank, 1902, *Glacial formations and drainage features of the Erie and Ohio Basins.* United States Geolgical Survey. Monograph 41,802p.

Schiner, George R., and Gallaher, John T. 1979, *Geology and groundwater resources of western Crawford County, Pennsylvania.* Pennsylvania Geological Survey. 4th Ser., Water Resource Report 46, 103 p.

Topp, Linda M., and Harrison, Samuel S., 1975, *False "bedrock" in glacial drift.* Bulletin of the Association of Engineering Geologists, V. XII, No. 4 p. 323-325

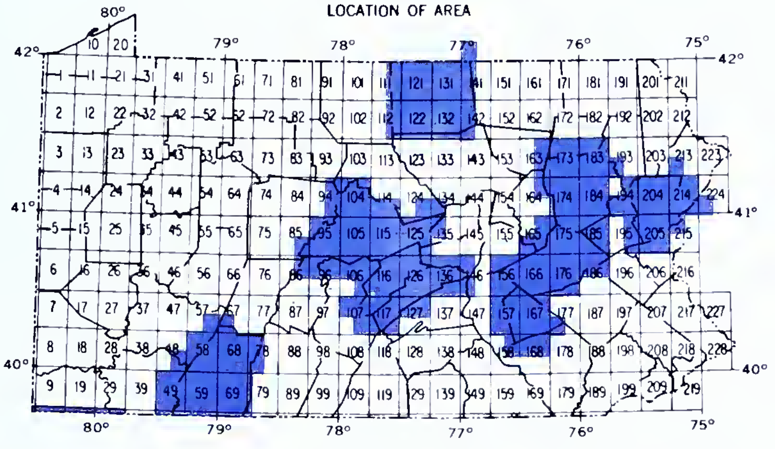
ORTHOPHTOQUADS

The U.S. Geological Survey produces general-purpose base maps that serve a wide range of needs. Now, in addition to the existing series of conventional line maps a new series of photoimage maps is being produced at a scale of 1:24,000.

An orthophotoquad consists of an orthophotograph or a mosaic of orthophotographs in standard quadrangle format with little or no cartographic treatment. Tick marks denoting the latitude and longitude and the State plane coordinates of the map projection are shown only at the map neatline. The Universal Transverse Mecator grid is fitted precisely to the plotted projection and is printed on the photoimagery as fine black lines without labels. For general orientation, the major highways and a few principal places or features are labeled. The map collar is composed in much the same style as for standard topographic maps.

Orthophotoquads portray by photoimagery an abundance of detail not found on conventional line maps. They can be used for land use information; site selection for industries, utilities, and public transportation; urban renewal and urban-suburban growth studies; development and conservation of natural resources; and flood hazard, pollution, and coastal wetland studies. Data such as timber, soil, and crop inventories can be plotted directly on the orthophotoquad, and reliable determination of acreage made. The orthophotoquad can be used to revise other maps or to serve as a base for making special-purpose maps.

The index map shows those quadrangles in Pennsylvania that are covered by orthophotoquads. A set of the orthophotoquads is on file for public examination at the library of the Pennsylvania Geological Survey, 916 Executive House, Harrisburg.



To obtain additional information about the availability of orthophotoquads or to place an order for maps contact the Eastern Mapping Center, National Cartographic Information Center, U.S. Geological Survey, National Center, Stop 536, Reston, Virginia 22092 (703) 860-6336. Price of paper copy is $1.25 each.

EARTH SCIENCE TEACHERS' CORNER

PROJECT FAMOUS (25 min.)

A geological look at details along the Mid-Atlantic Ridge. Good footage from *Alvin* dives. Volcanic vs. tectonic influences on topography. 1979. University Media, P.O. Box 881, Solana Beach, CA 92075.

MOONWALK (40 min.)

Dramatic documentary of the Apollo II story from blastoff to splashdown. Beautiful footage, all phases. 1976. Learning Corp. of America, 1350 Avenue of the Americas, New York, NY 10019.

OUR DYNAMIC EARTH (23 min.)

A brief look at plate tectonics, well done. Examples of subduction, convergence, translation. Almost half the film is observations from the submersible *Alvin*, including life sustained by water warmed and vented along the mid-Atlantic rift. 1979. Karol Media, East 36A Midland Ave., Paramus, NY 07652.

PLANET MARS (29 min.)

Excellent. The story of Martian exploration, from early observations by telescope to the Viking lander and its messages. 1979. NASA, Code LFD-13, Washington, DC 20546.

VOYAGER JUPITER ENCOUNTERS (17 min.)

Voyager 1 and 2, from flight plan to time-lapse sequences of Jupiter's rotation and atmospheric circulation; close-ups of the red spot and moons, including volcanic eruption on Io. Real footage backed up by clear computer simulation. 1979. Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91103.

GEOTHERMAL ENERGY FROM HOT DRY ROCK (14 min.)

Los Alamos Scientific Lab experiments with extracting heat energy from hot, dry rock by use of two wells, controlled fracturing and water circulation. Result: water at 130°C, good for 5-10 megawatts. A good, straightforward statement of a full scale experiment. 1978. Los Alamos Scientific Laboratory, Report Librarian, P.O. Box 1663, Mail Stop 364, Los Alamos, NM 87545.

GROUNDWATER - A PART OF THE HYDROLOGIC CYCLE (29 min.)
A high quality film covering many aspects of the difficult subject of groundwater, from recharge to discharge; excessive pumping, artificial recharge, pollution and solution, geothermal power. 1979. Cherry Film Productions, Ltd., 25 Bell Street, Regina, Saskatchewan S4S 4B7.

BIG HOLE DRILLING (25 min.)
A fascinating look at the relatively new technology for drilling holes up to 10 feet in diameter to depths of thousands of feet using modified oil well methods. Developed primarily at the Nevada Test Site. 1979. U.S. Department of Energy, Nevada Operations Office, P.O. Box 14100, Las Vegas, NV 93114. Attn: Public Information Office.

EARTHSPACE-OUR ENVIRONMENT (15 min.)
Dwells primarily on earth's magnetosphere through the work of many scientists (Van Allen etc.). Spectacular shots of auroras and solar flares. 1978. NASA, Lyndon B. Johnson Space Center, Public Information Branch/AP3, Film Distribution Library, Houston, TX 77058 for NASA Regional Film Library serving your state.

OUR MINERAL WORLD (29 min.)
Brian Skinner and others discuss our dependence on minerals; source areas, consuming areas, shipping recycling, re-mining, remote sensing and global interdependence. A good review of the finite resource problem and a plea for intelligent world-wide cooperation. 1979. Index Film and Television Library, Ltd., 12 Charlotte Mews, London WIP ILN, England.

NEW STAFF MEMBERS

DON A. GADDESS

Don A. Gaddess joined the Oil and Gas Regulation Division in December, 1979 as an inspector of oil and gas wells.

After receiving his B.S. in Petroleum Geology from Tulsa Univ. in 1958, he worked for a geological consulting firm. From 1959 to 1971 he was company geologist with the North Penn Gas Co. where he prepared sub-surface structural geologic maps, examined well samples and seismic reports relating to the company's activities regarding drilling and storage. Since that time he worked as a consultant geologist and lease broker until taking on inspection duties in Erie and Crawford Counties.

CHRISTOPHER D. LAUGHREY

Christopher D. Laughrey, a native of Cambria County, joined the Survey in February, 1980 as a geologist with the Oil and Gas Geology Division in Pittsburgh.

Chris completed his B.S. degree at the University of Pittsburgh at Johnstown in 1977 and has done graduate work in geology through Bowling Green State University and in exploration geophysics at the University of Houston.

Chris spent 2-1/2 years working as a geophysicist for Western Geophysical Company in Houston, Texas, primarily involved with offshore seismic investigations in Alaska, California, the Baltimore Canyon and the Fiji Islands.

He is assigned to the Pennsylvania oil and gas fields project preparing a new oil and gas fields map of Pennsylvania.

FRANK E. MACKEY

Frank E. Mackey, who comes from Bradford, Pa., is now part of the Survey's oil and gas inspection team. Frank graduated from the University of Pittsburgh with a B.A. degree in 1974.

Prior to 1963 he had been associated with the drilling industry and during 1970-1974 he worked full-time and part-time dressing tools on BuCyrus Erie 24's and 28's while attending college.

He joined the Survey's Division of Oil and Gas Regulation, as an Oil and Gas Inspector on November 23, 1979.

GERALD W. WILDERS

Gerald Wilders is a mining engineer who is a native to the beautiful mountain area of Saltlick Township, Fayette County, Pennsylvania.

A graduate in civil engineering from the University of Saskatchewan, Canada, he began working in coal mines during summer vacations. After graduation, he worked briefly on construction projects before beginning his mining career with Eastern Associated Coal Corp. Gerry also worked for a period with the Pennsylvania Railroad and later joined the U.S. Treasury as a Natural Resource and Valuation Engineer.

Before joining the Oil and Gas Division as a mining engineer in December, 1979, he did mine engineering and appraisal work independently.

PENNSYLVANIA GEOLOGICAL SURVEY STAFF

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Gerald W. Wilders, *Mining Engineer*

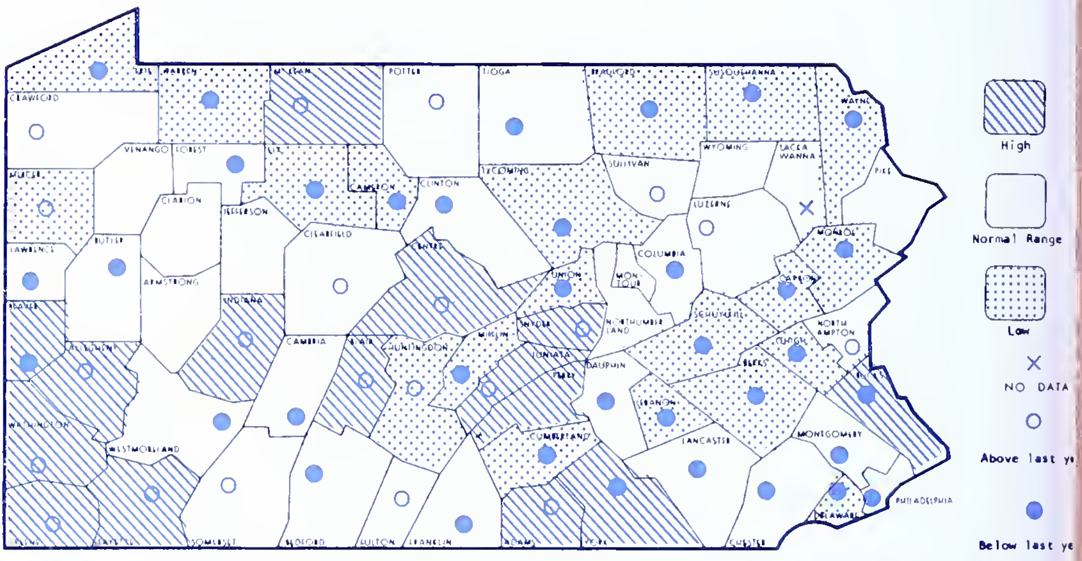
TOPOGRAPHIC DIVISION

In Cooperation with The U.S. Geological Survey

GROUND WATER DIVISION

In Cooperation with The U.S. Geological Survey

GROUND-WATER LEVELS
FOR
MARCH 1980



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DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY
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PENNSYLVANIA GEOLOGY

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THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 11/3

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: A portion of Baers Rocks along the Appalachian Trail on the crest of Blue Mountain, at the border between Schuylkill and Lehigh Counties. These rocks are the broken, upturned edge of the 1600-foot thick Silurian (440 million years old) Shawangunk Formation, here a cross-bedded conglomeratic quartzite. These massive joint blocks illustrate characteristic rock weathering on ridge crests, providing a source for down-slope accumulations of boulders. Photo by J. P. Wilshusen.

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JUNE 1980

FROM THE DESK OF THE STATE GEOLOGIST . . .

ACHIEVEMENTS YES, APOLOGIES NO

There are some who have been saying in recent years that the United States, with approximately 6% of the world's population, has no right to be consuming some 30% of the world's annual production of mineral resources. Such remarks have been particularly stimulated by the unsettled world energy situation.

I, for one, am not yet ready to apologize for the extent of our consumption. To begin with, the early settlers of our nation had no forehand knowledge that this was a continent blessed with an abundance of mineral resources, including coal, oil, and natural gas. We owe no apologies for our early pioneers who had the initiative to move westward and who braved unbelievable hardships as they settled in the wilderness. Nor do we owe apologies for the prospectors and miners who endured and conquered physical dangers and economic risks to locate and develop our mineral deposits, and are still doing so today at greater and greater costs as the easily discovered mineral resources are long gone.

And we should not be apologetic for the initiatives of industry and labor whose combined efforts created our industrial society and standard of living which is the envy of both developed and undeveloped nations of the world—even as our industrial society is the very basis for our massive mineral resource consumption.

America's technological and scientific genius which has created the marvels of transportation, communication, housing, disease controls, and scientific agricultural should also not be asked to apologize for their achievements, even as they too have added to our consumption of resources.

The challenge to our society is not simply to consume less out of some sense of guilt. We should rather eliminate wasteful procedures so that our known mineral resources will go farther, and improve our technology to find deeply hidden resources and to utilize low grade resources.

The underdeveloped nations have every right to aspire to greater use of mineral resources, greater industries, and high standards of living. But the challenge to those nations is to take the initiative to find and develop the resources in their own back yard. Our national achievements or our levels of consumption are not the cause of their underdevelopment and underconsumption.

While some countries have been blessed with a greater abundance of mineral raw materials than others, and some nations have moved far along to depleting their rich, easily discovered mineral deposits, the fact is that the world is not really running out of mineral raw materials. There remain in the earth's crust both deeply hidden, highgrade deposits, as well as known low-grade deposits of vast dimensions waiting to be "harvested" by improved technology. These challenges are compounded by political barriers which so often prevent freedom of movement of mineral resources between have and havenot nations.

Yes, our country is a major consumer. Yes we have challenges to face in order to sustain our standards of consumption. Those challenges call for achievements, not apologies.

Arthur A. Socolow

FRACTURE TRACES AND WATER WELLS, A REVIEW

Larry E. Taylor, Hydrogeologist

This is a brief history of the studies which have led to the present use of aerial photographs and remote sensing imagery to identify fracture traces and lineaments which are then utilized in an attempt to locate high yield water wells. Some of the following information is from an unpublished report by Snyder (1975) that gives a good review of modern works pertaining to fracture traces and ground water. It is noteworthy that research and discussion on fractures and linear features have been cited in the literature since the 1800's.

Hobbs (1904, 1911) has been generally credited with the introduction of modern techniques of study of natural linear features. He was preceded by over a century of less rigorous investigations that are discussed by Hodgson (1974). Rich (1928) was apparently the first to report about the observation of linear features from the air. He recognized linear vegetational, tonal, and topographic alignments while flying over the limestone areas of Oklahoma. He suggested the use of aerial photographs to further study these linear features which he related to bedrock jointing. Little work was done using Rich's idea until the major oil companies became interested in the use of fracture trace studies for their exploration programs in the early 1950's (Keim, 1962, p. 2).

In 1955, Lattman and Olive presented a brief note showing that the rate of dip of limestones in the semi-arid Stockton Plateau of Trans-Pecos region of Texas could be established from mapping joint sets on aerial photographs. Blanchet and Molland (1957), in separate papers, used aerial photographs to map linear features in western Canada. They both introduced theories as to the mechanisms causing fracture traces and lineaments. In 1958, Lattman published a paper presenting techniques for mapping fracture traces and lineaments and introducing his nomenclature for linear features.

None of these studies made any mention of the use of fracture traces and lineaments to locate water wells. The first published attempt to correlate high yield wells with fracture traces was described by Meisler (1963). This study found no significant relationships between the specific capacity of water wells and their location with respect to fracture traces (Meisler, 1963, p. 33).

Before continuing, it should be mentioned that use of linear valleys, depressions, and other natural alignments for well location is not new. A few drillers, "water witches," and geologists have been aware of topographic influence on the degree of bedrock fracturing and, thus, well yields for many years. Unfortunately, very little information about this has been published, although there are a few instances. A paper by Graeff (1953) deals with the use of trough like linear depressions to locate water wells. This report is in some respects more credible than some of the recent literature because the depressions were correlated to prominant joint trends in Graeff's study area. This use of natural linear depressions relied on subtle changes in topography rather than aerial photographs to locate water well drilling sites. Some modern authors contend that this is still the best method to locate wells (Nutter, 1973, p. 26).

Lattman and Parizek (1964) attempted to demonstrate the utility of fracture traces for the location of high yield wells in the Nittany Valley. Their investigation had two basic deficiencies: 1) There was an insufficient number of wells intentionally located on and off fracture traces; 2) Little attempt was made to separate the influence of fracture traces from other hydrogeologic variables that affect well yields.

Siddique and Parizek (1971) published a paper intended to "satisfy skeptics" (p. 1296) as to the utility of fracture traces for high yield well locations. Statistical analyses were used to attempt to isolate the different hydrogeologic factors influencing well yields and thereby show that the most important factor in a given geologic setting was location with respect to fracture traces. A basic problem with this study is that many of these hydrogeologic factors are not easily separated which results in the authors having to make certain assumptions that are not acceptable to all investigators.

A considerable amount of literature pertaining to fracture trace location of water wells has been published in the 1964-1979 period. None can be said to fully demonstrate the utility of the method because they have not addressed themselves to the inherent theoretical problems that exist with the method. Some of these problems are as follows: 1) variation in joint density with lithology and bedding thickness, 2) paucity of vertical fractures in some geologic settings, 3) refraction of inclined joints at lithologic contacts and the refraction of vertical joints at inclined lithologic contacts, 4) signifigraphs, and 5) statistical advantage of the fracture trace method as opposed to a strict topographic method.

In summary, the identification of fracture traces on the ground and on air photos has a long history. In some geological settings, the location of such fracture traces has been an apparent aid in chosing sites for high yield water wells. In other geological settings, however, well data indicate that the use of fracture traces has not been particularly helpful for picking favorable water well sites.

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DISTINGUISHED EDUCATION AWARD TO STATE GEOLOGIST

In recognition of services rendered to geologic education, Dr. Arthur A. Socolow, Director of the Bureau of Topographic and Geologic Survey, has been selected by the National Association of Geology Teachers as the 1980 recipient of the Ralph Digman Award. Named after an outstanding educator and founder of the Association of Geology Teachers, the award is bestowed annually upon an individual who has made outstanding contributions to geologic education while not directly serving as a teacher.

In granting the award to Dr. Socolow, the Association of Geology Teachers cited his many years of personal attention and services to students and teachers of all grade levels, as well as his leadership in developing and providing educational geology materials at the Bureau of Topographic and Geologic Survey. Under Dr. Socolow's guidance, the State Geologic Survey has prepared a nationally acclaimed series of nine geology booklets on subjects of widespread interest, a set of geologic resource maps of Pennsylvania, a series of geologic guides to Pennsylvania's State Parks, and a variety of rock and mineral specimens to help stimulate the beginning geologist. Since these educational materials were initiated under Dr. Socolow's direction in 1962, over 2 million students, teachers, and general public have utilized these elementary geologic aides.

In accepting the award at the Annual Meeting of the National Association of Geology Teachers' Eastern Section, held at New Kensington on May 3rd, Dr. Socolow noted that such services for students and the public enable them to better understand and appreciate the complexities and importance of the geology which they encounter in their daily lives. Dr. Socolow stated, "The educational geologic services and materials which we provide constitute a proper balance to the highly scientific geology reports which are prepared by our outstanding staff of geologists. I am pleased that this broad program of activities by the Pennsylvania Geologic Survey thus covers the needs and interests of our entire citizenry."

Decoding A Fossil Trail

Wayne F. Downey, Jr., Geologist
R. E. Wright Associates

One of the more puzzling paleontological problems of central Pennsylvania is the classification and origin of the index fossil *Arthrophycus alleghaniensis* commonly found along bedding planes in the Tuscarora sandstone of lower Silurian age. The Tuscarora trends northeast-southwest and underlies many of the Appalachian mountains from southeastern New York to Maryland. (Figure 1).

Near Mt. Union (Figure 2) *Arthrophycus* occurs as bundled cylindrical fillings of tunnels on the lower bedding surface and contact of the Tuscarora quartzite. (Figure 3A). The quarry at Mt. Union exposes 58 feet of Tuscarora overlying olive-green, silty, fissile shales.

The sandstone is well sorted, fine (.2 mm) to medium (.5 mm) grained and silica cemented. It contains minimal argillaceous material and in most areas only traces of iron in the form of localized ferrous stains with minor hematite and siderite granules.

The Tuscarora is clean, containing less than 3% clays, and silt with low trace element content. The sand grains fall between .4 and .6 roundness parameters. The Tuscarora has probably been reworked, representing a second or third stage sandstone derived from earlier quartzites.

The Tuscarora (Schwartz, 1934) contains a shallow marine fauna and is represented by a few fragments of eurypterids, a few brachiopods and a very prominent fossil burrow, *Arthrophycus*. (Figure 3). Since some samples exhibit hard-bodied marine fossils, a shore environment is suggested as a possible site of deposition.

The curving stems of *Arthrophycus* are simple or usually terminate in bunches, which gradually curve upward in section. The surface of the raised cylinders frequently show regularly spaced transverse ridges. These ridges are curved smoothly and extend the total circumference of the cylinders. (Figure 5). The branches are found along bedding planes in disarray, with no apparent pattern. Branches bisect and crosscut other branches indiscriminately. (Figure 6). Vertical orientation is minimal, implying the branches are the casts of restricted shallow feeding burrows made by perhaps a marine annelid (worm) which churned the beach sand 400 million years ago. (Figure 3B).

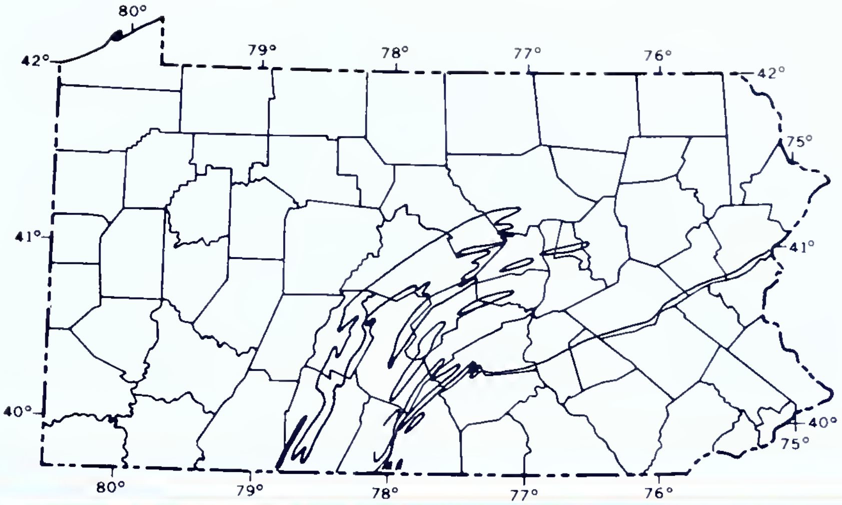

Figure 1. Areas of Pennsylvania where the Tuscarora sandstones occur.

The "annelid" most likely formed membranous tubes utilizing an organic gelatinous substance secreted through its cuticula. The binder allowed the preservation of the fossil burrows seen today. (Figure 4).

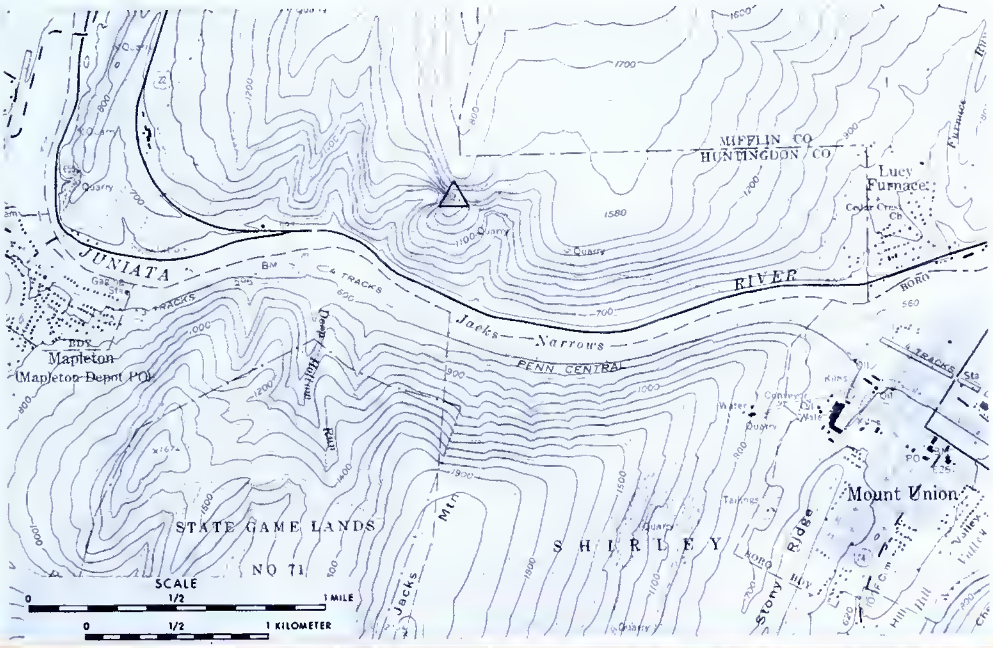

Figure 2. Topographic map of Mt. Union area where *Arthrophycus* occurs near top of Jacks Mountain in an abandoned quarry.

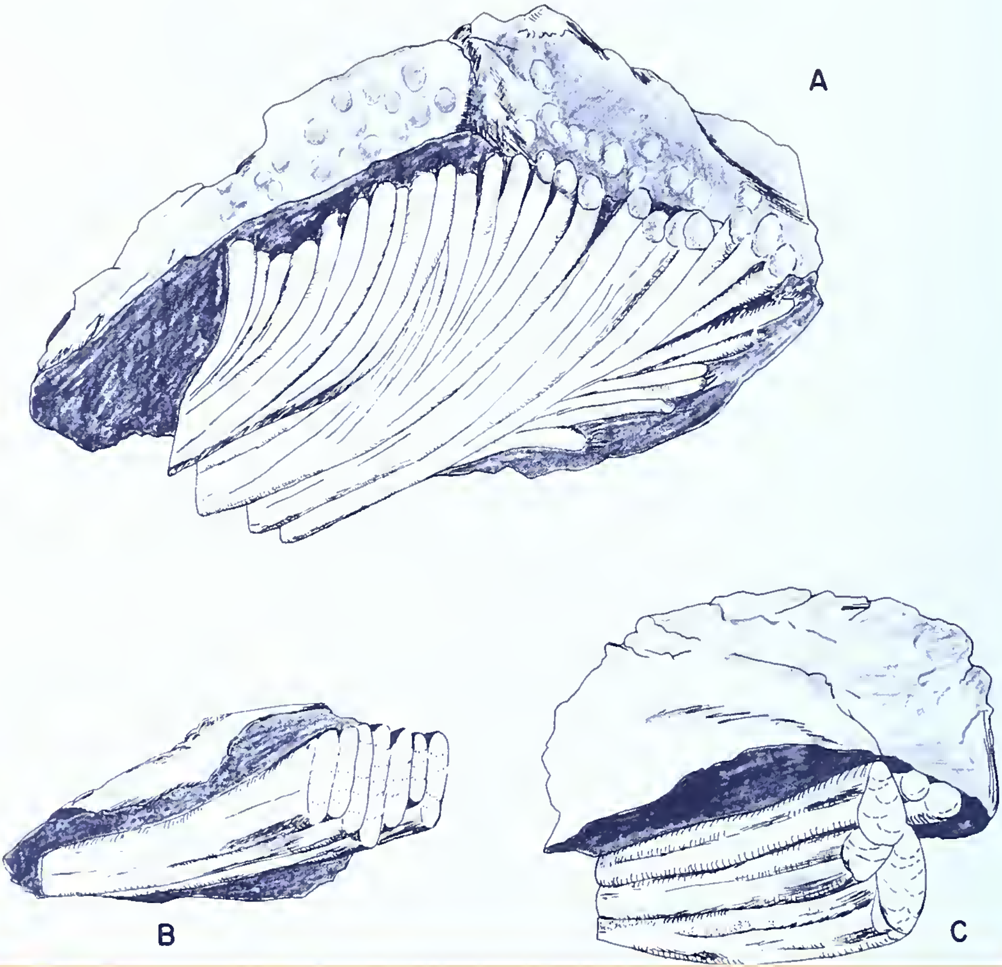

Figure 3. Schematic depictions of *Arthrophycus* detail illustrating common mode of termination and banding.

Upon examination of thin sections of *Arthrophycus* tubes, it becomes evident that the creature responsible for them was a deposit-feeder, that is, it would burrow and feed on sand containing organic detritus supplied by organisms which died in the shallow littorial zone of a Silurian sea. The sand was "eaten," ingested, and passed through the digestive tract where nutrients were extracted. Finally, the biochemically bleached sand grains were expelled from the posterior of the worm through a large intestine where they backfilled the feeding tube. The excretion consisted primarily of ammonia, urea, and nitrogenous compounds. These are easily dissolved and are absent from the fossil record, but excess iron, not used in manufacturing of hemoglobin, could have been excreted through the skin periodically in high concentrations and collected as a pronounced

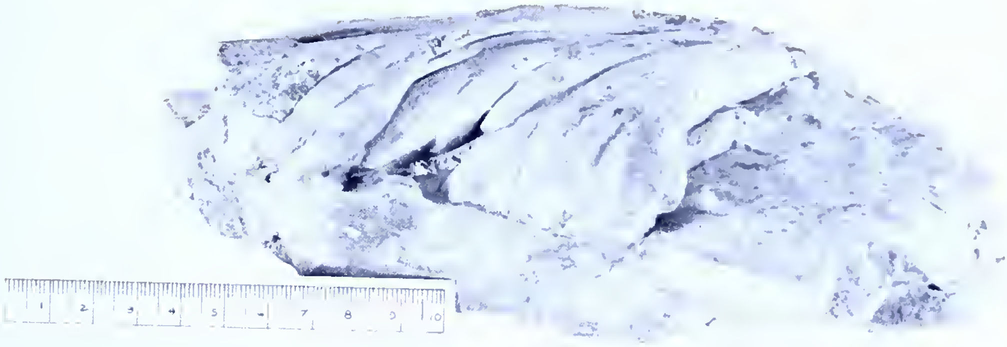

Figure 4. *Arthrophycus*. From near Mount Union, Huntingdon Co., Pa. W.P.M.M. Sample #T33. Photo courtesy of William Penn Memorial Museum.

iron stain on the peripheral edges of the burrows. (Figure 3A). "This mechanism may be aided by sulfur contained in the organic binder, preferentially reacting with additional iron in surrounding sediment precipitating hematite and various iron sulfides." (Roger D. K. Thomas - personal communication).

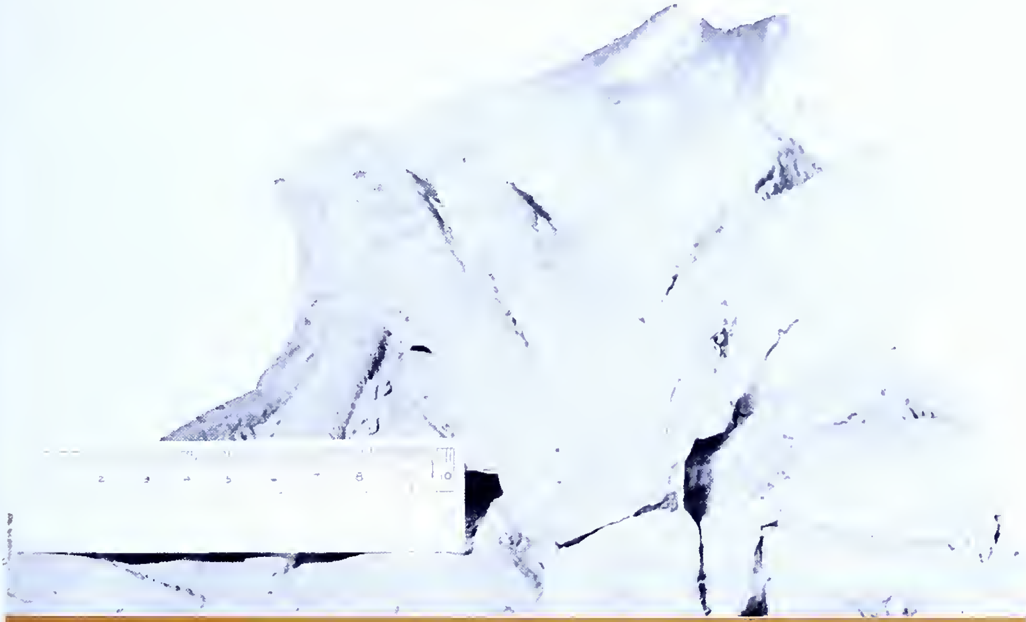

Figure 5. *Arthrophycus*. From east slope of Loop Mountain, Frankstown Twp., Blair Co., Pa. W.P.M.M. No. T6. Shows branching terminations and "ribbed" structure.

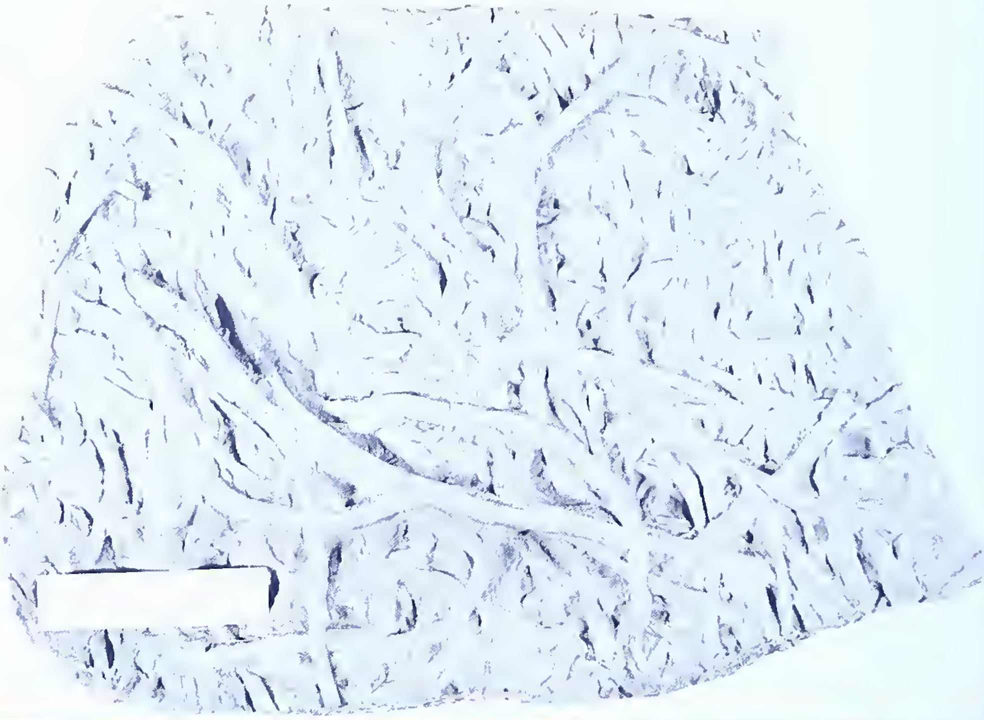

Figure 6. *Arthrophycus*. Locality unknown, from W.P.M.M. collection, Sample No. T8. Illustrates common intersecting branching burrows.

Most living deposit feeders feed in mud substrates or in rich organic oozes. These are unusually unsegmented; however, *Arthrophycus* was a sand feeder, and had very prominent segments. It apparently could subsist on minimal organic material, and adapted prominent segments for rapid locomotion through loose sediment. This is accomplished by rapid contraction of the longitudinal muscles on both sides of a segment with a concomitant expansion of another segment producing rhythmic, paristaltic waves of constriction. The last few posterior segments expand against the inside walls of the tube causing frictional resistance and imprinting characteristic ridges observed in fossils today. (Figure 3C).

A more difficult structure to explain is the dichotomous branching terminations that are commonly exhibited by *Arthrophycus* burrows. Asexual reproduction may explain the off-shoots. Regeneration of a complete individual from artifically separated segments is possible through spontaneous fragmentation of the body. Heads could possibly have been produced on almost any segment, following simple fragmentation. The currently existing family, Nephtyidea, a marine annelid, is characterized by numerous segments, rather wide girth (up to 7 mm or 8 mm) and lengths to 60 cm or more. Within the Nephtyidea family subspecies *Agaophamus circinata*, this type of reproduction is relatively common today. It has been calculated that a single individual could give rise to 15,000 others within a two month period. This proliferation would result from approximately 25 separate individuals being produced in a single day by one parent. (Pratt 1935).

A possible explanation for *Arthrophycus* is here suggested. Forming in one tube each *Anthrophycus* offspring selected a different direction to eat its way to the sediment surface. The young annelids surely must have had a voracious appetite and needed substantially more nutrients to grow than the sand provided. Upon reaching the surface, they probably sought out simple seaweed-type plants to parasitically remove juices from them. Whereupon growth would have been rapid, the adolescent annelids would burrow back into the substrate to lead more sedentary lives. There are a number of species living today in the intertidal zone within beach depositional environments which follow a very similar pattern of life. This explains both the sudden junctures of *Arthrophycus* burrows and also the high angle surface trajectories the burrows show soon after disjunction.

No fossil example exists of the actual animal organism which produced the burrow *Arthrophycus*, so most of the theory as to its appearance and classification is purely speculation.

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Mineral Collector's Field Guide, The Northeast, by Bill Shelton and Bud Webster. Published by Mineralogy, P.O. Box 504, Wallingford, Ct. 06492. $8.50.

This book attempts to provide information on what the authors consider to be some of the premier collecting localities in northeastern United States and southeastern Canada. The work is not intended to be a complete listing of collecting localities but rather a guide to the geologically interesting and/or specimen-rich localities and gives more details than could be included in a more general guide. Of the 50 localities described two are in Pennsylvania. One is the Faylor Middlecreek Quarry in Winfield, PA and the second is the Meckley Quarry in Herdon, PA.

LANDSLIDES IN BEAVER COUNTY, PA.

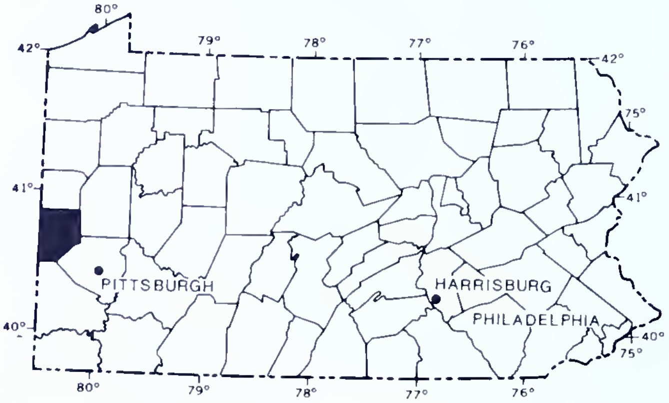
A new map showing over 3,000 landslides and areas most susceptible to future landsliding in Beaver County, Pa., has been published by the U.S. Geological Survey, Department of the Interior.

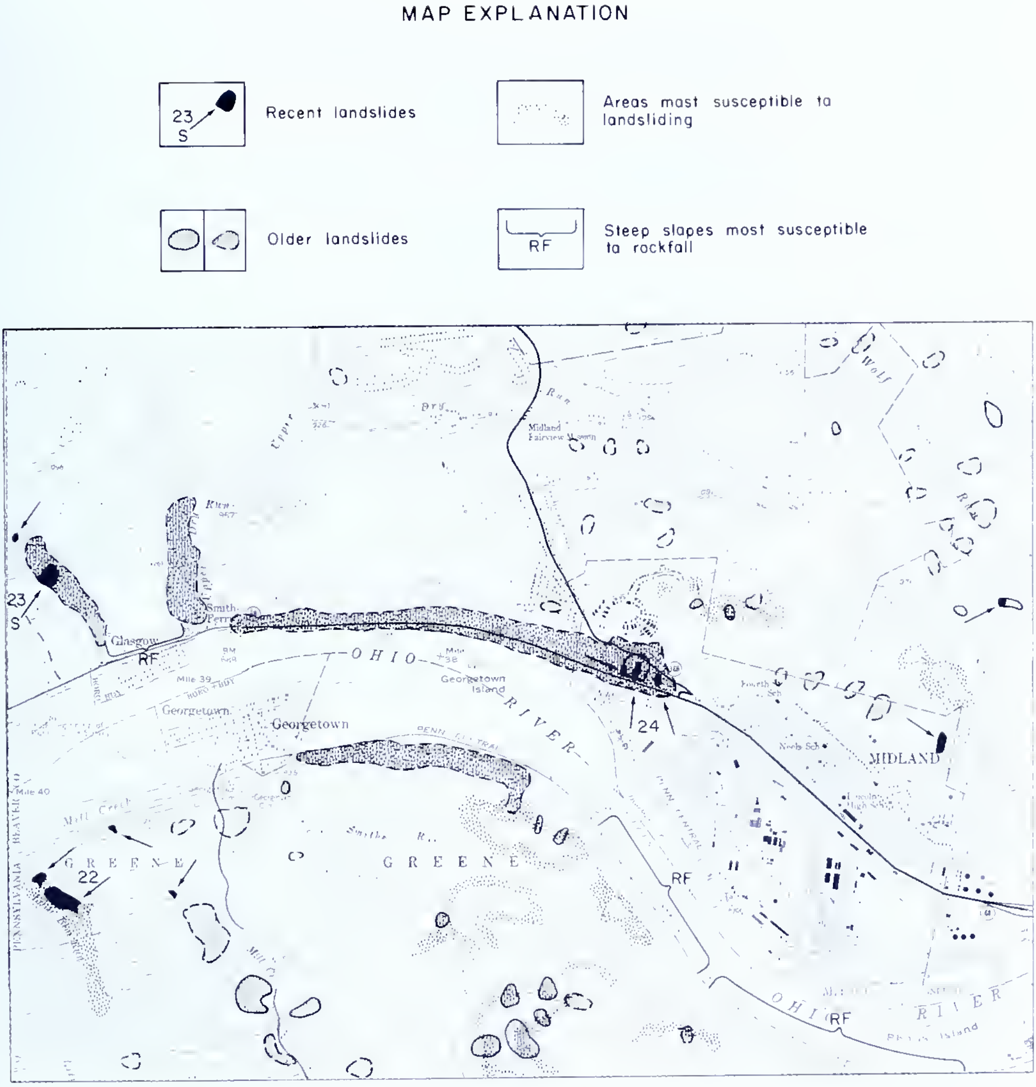
The map covers a 440-square-mile area in the western part of the state, about 15 miles northwest of Pittsburgh and is part of a series of 1:50,000-scale (1 inch represents about 1.25 miles) county maps that identify areas with potential slope stability problems that could be significant to regional development in the Greater Pittsburgh region.

Using shading and symbols, the map identifies more than 250 recent landslides and about 3,000 older landslides. Also shown are selected examples of ground slumping, areas most susceptible to landsliding, and steep slopes susceptible to rockfall. More than 90 percent of the recent landslides are small, generally less than 100 feet (30 meters) in width or length.

Although a few recent slides have been triggered by natural causes, such as unusually high amounts of rainfall, most have been man-generated and occur near roads and construction sites.

Many of the slides are triggered by manmade modifications of sensitive slopes. These activities include excavating at the base of a slope so that the slope becomes oversteepened, overloading a slope with fill and causing instability, altering drainage conditions that





affect not only surface water but ground water as well, and the vibrations caused by increased heavy construction such as blasting and pile driving. Any of these changes can reduce the shearing strength of the earth material and cause slippage.

An example of the map's content is illustrated in the adjacent figure.

Copies of the map, titled, "Map Showing Landslides and Areas Most Susceptible to Sliding in Beaver County, Pa.," and released as Miscellaneous Investigations Series Map I-1160, can be purchased for $1.25 each from the Branch of Distribution USGS, 1200 South Eads St., Arlington, Va. 22202. Purchases must include check or money order payable to the U.S. Geological Survey.

PREVENTING WATER WELL EXPLOSIONS IN GAS AREAS

Water well installations in homes or buildings located in oil and gas producing areas of Pennsylvania should be vented to prevent the possible accumulation of explosive mixtures of natural gas within the building. This recommendation is being made by State Geologist Arthur A. Socolow of the Department of Environmental Resources with the hope that personal injury and property damage may be avoided in the future by making the public aware of the problem. Over the years a number of damaging explosions have occurred which have been attributed to such natural gas accumulations.

In the oil and gas fields of western and northern Pennsylvania the natural gas frequently occurs at shallow depths and has the ability in certain situations to move upward through cracks and pore spaces in the rocks until the gas reaches the water table.

Water wells provide a favorable channel along which the gas may rise into the basement of the overlying building.

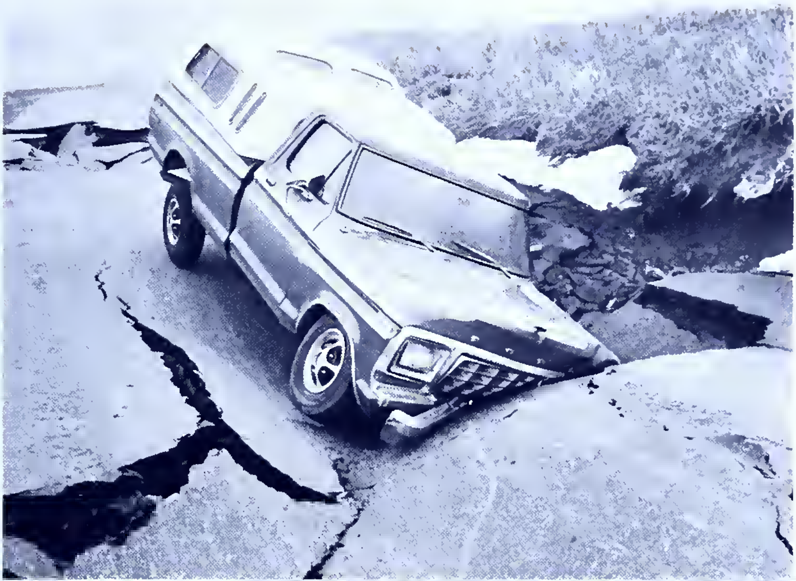
Venting a water well installation basically involves a pipe which leads from the well head to a location outside the building. Such well vents for new or existing wells may be installed by competent water well drillers or pump installers.

To help interested persons to understand where Pennsylvania's oil and gas producing regions are located, DER's Bureau of Topographic and Geologic Survey has prepared a page sized map showing the oil and gas field areas of the Commonwealth. This map is available from the Survey at no charge by writing to P.O. Box 2357, Harrisburg, Pa. 17120.

TO REPAIR A SINKHOLE

In February 1979, sinkholes opened under Bullfrog Valley Road in Derry Township not far from the Hershey Convention Center. It took almost a year to conduct a foundation investigation, design the remedial procedures and repair the roadway before it could be opened to traffic again in January 1980. That is a short time when one considers the amount of construction that had to be designed and executed.

The area of sinkhole collapse was bridged by a reinforced concrete span supported by caissons 41 feet long, drainage control structures were installed, subgrade replaced and the roadway repaved. The accompanying sequence of photographs shows collapse, repair and present condition.



COLLAPSE

REPAIR

PRESENT

Photos by W. Bolles

FAMOUS PENNSYLVANIA MINES FEATURED IN STATE MUSEUM EXHIBIT

Famous Mineral Localities Exhibit, a colorful display relating to the ore deposits at Cornwall, Lebanon County, and the French Creek Mines, St. Peters, Chester County, is being shown at the William Penn Memorial Museum, Third and North Sts., Harrisburg.

The subject treats the mineral origins, and presents a brief historical sketch of the world-famous iron deposits at the two Pennsylvania sites. In addition, many fine specimens collected at both localities are displayed with photographs and other artwork. Cornwall Furnace, near Lebanon, is maintained as an historic site by the Pennsylvania Historical and Museum Commission (PHMC).

The exhibit, organized by Donald Hoff, curator of earth sciences at the State Museum, continues through Sunday, Aug. 3.

The Cornwall deposits were an important source of iron ore from colonial times. Mining began at Cornwall in 1742 when ironmaster Peter Grubb completed construction of the original Cornwall Furnace. This furnace was remodeled in 1857. More than 100-million tons of Cornwall commercial ores were mined before the mines were finally exhausted in 1973. Copper, silver, gold, cobalt, and sulfur, in addition to iron, were obtained from the ores during the 20th century.

The French Creek Mines deposit supplied a moderate amount of iron ore beginning in 1846, with final depletion of ore in 1928. This locality was probably most important as a source of excellent mineral specimens which are now in the collections of many museums throughout the world. Most of the French Creek Mines specimens displayed in this exhibit are from the John Frankenfield Collection which was purchased by the Pennsylvania Historical and Museum Commission in 1973.

The Central Pennsylvania Rock and Mineral Club, Inc. will hold its Fifteenth Annual Gem, Mineral & Jewelry Show in the Tile Room of the Zembo Temple, 2801 N. Third Street, Harrisburg, on Saturday, September 6, 10 AM to 9 PM, and on Sunday, September 7, 10 AM to 5 PM.

There will be mineral, gem lapidary, fossil, and carving exhibits; demonstrations by club members; and dealers who will display minerals, fossils, gemstones, and jewelry.

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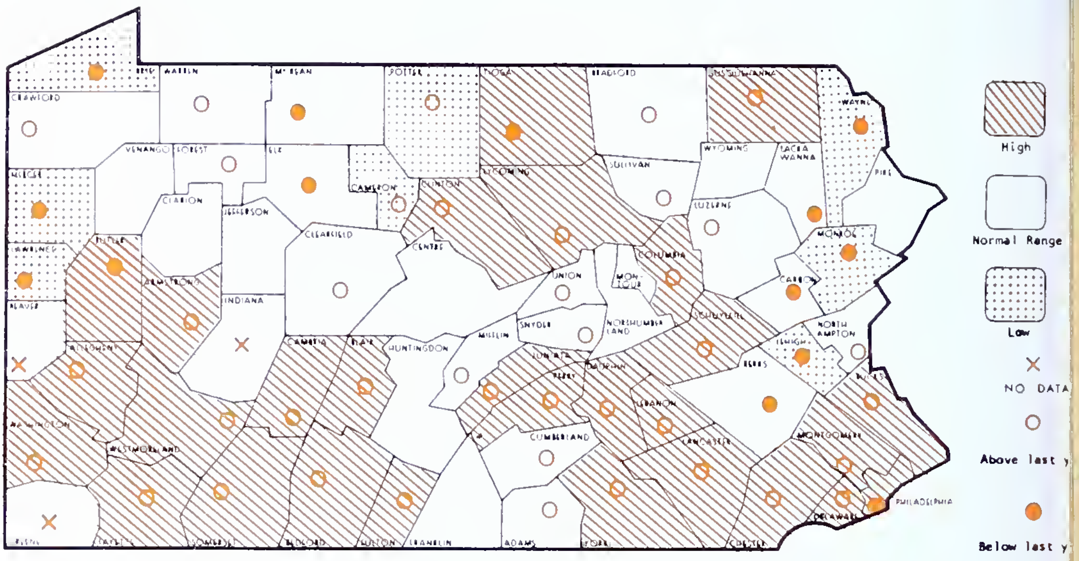

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PENNSYLVANIA GEOLOGY

THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 11/4

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Tinicum Marsh, a registered National Natural Landmark located at the boundary of Philadelphia and Delaware counties. Part freshwater and part saltwater, this is a critical and delicate physical feature and biological sanctuary closely surrounded by urban developments.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

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AUGUST 1980

FROM THE DESK
OF THE
STATE GEOLOGIST

THE EXPANDING ROLE OF ENVIRONMENTAL IMPACT STATEMENTS

The advent of environmental impact statements (EIS) several years ago was properly heralded as a constructive, formal procedure designed to evaluate, in advance, the impacts which a proposed project would have on the environment. If unfavorable reports were found to be likely, the project could be modified, or even cancelled.

In the early days of this process, the primary concern was to avoid disastrous impacts upon our biological environment (plant and animal life) and upon our physical environment (soil erosion, water quality, etc.) However, as time went by, the definition of environment began to change and environmental impact statement guidelines called for the inclusion of assessment of the socio-economic impacts of each proposed project. Thus, we now find that the EIS deals not only with the physical and biological sciences, but with the less-than-exact subjects of sociology and economics. Of course, those aspects of impact are important; the number of new jobs which may be created by a project vs the number of businesses or farms displaced; the increased tax revenue from new industry attracted by the project vs the increased costs of schools and sewer lines due to prospective new houses and factories.

Having expanded into the realm of socio-economics, the EIS's should now go one step further and evaluate the geo-political and international aspects of each project. An obvious example would be a coal-burning power plant which not only would support our domestic coal producing industry, but would make us less dependent on foreign oil - a major economic, military, and international impact. Less obvious might be a proposed factory (even with related highway and energy needs) whose new and efficiently produced products could compete on the world market and reduce our imbalance of payments ratio. Or a new fertilizer or farm equipment installation which enables the U.S. to produce more food for export to a hungry world. True, not each and every environmental impact of such installations is beneficial - they rarely are. But despite some additional energy demands, some local displacements, some community needs such as schools and sewer systems, the overall benefits to our national and international position may be highly desirable.

The Pennsylvania Geological Survey is involved in the review process of environmental impact statements. We look for a thorough

(continued on page 32)

Arthur A. Socolow

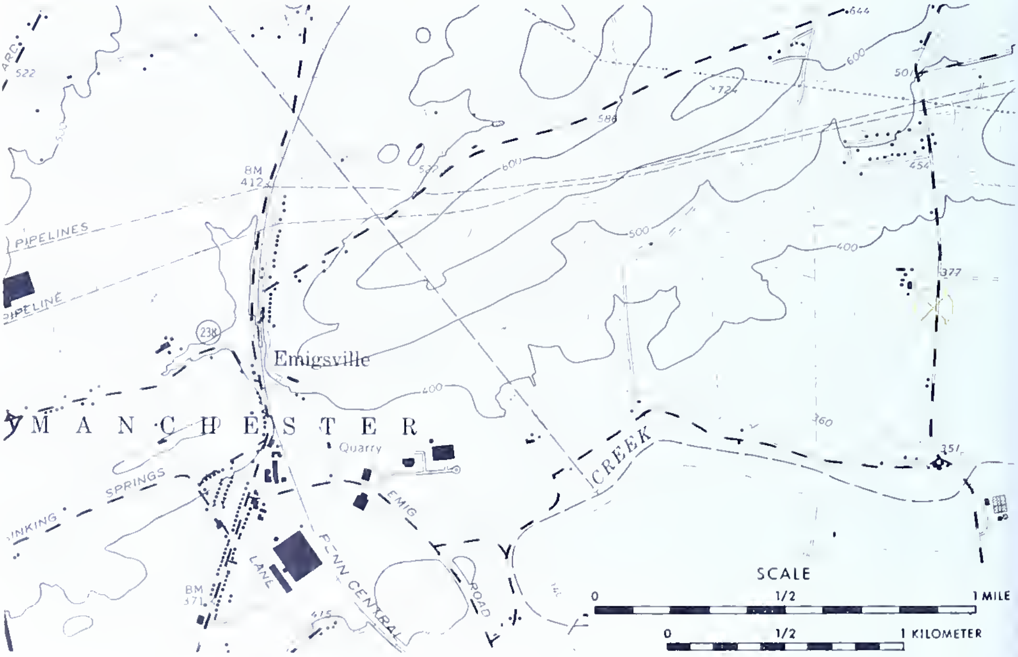
UNUSUAL SINKHOLE OCCURRENCE AT RUDY COUNTY PARK, YORK COUNTY, PENNSYLVANIA

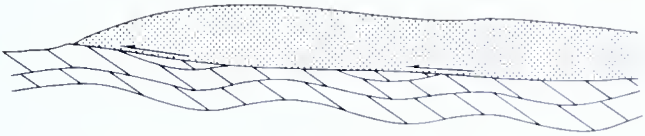
Jeri L. Jones
York County Parks

Sinkholes are commonly found in areas underlain by limestone and dolomite. In the York-Hanover Valley of York County, Pennsylvania, sinkhole-cave associations are common in the Vintage, Kinzers and Ledger dolomites, all of Cambrian Age.

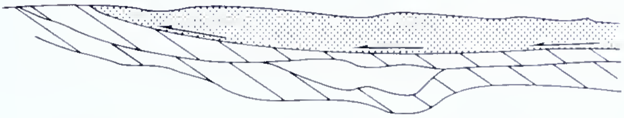
There was a recent discovery of a previously unknown sinkhole of particular interest at Rudy County Park. During the afternoon of February 24, 1980, an unidentified person was riding a horse in John Rudy County Park, located on Mundis Race Drive, about 1.32 miles east of Emigsville. Although Rudy Park is the headquarters of the county park system the property is not yet developed. Riding on one of the unimproved dirt roads near the northern boundary of the park the hoof of the horse suddenly fell into what appeared as a typical groundhog hole. With the entire leg of the horse sinking into the hole the weight of the horse forced more soil downward. After a few minutes there was a hole measuring 6 feet in diameter and 8 feet deep with the horse lying on its back at the bottom. After park personnel with a Caterpillar bulldozer worked for several hours the animal was safely freed.

How does this horse story relate to the area geology and sinkholes? Geologically the location of this event took place within the

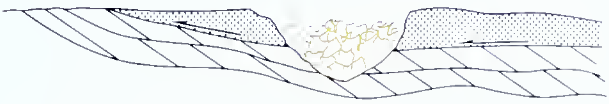




A. CROSS SECTION SHOWING THE ANTIETAM QUARTZITE THRUST OVER THE VINTAGE DOLOMITE.



B. EROSION LEVELS ANTIETAM QUARTZITE AND CREATES SOLUTION OPENING IN VINTAGE DOLOMITE.



C. COLLAPSE OF ANTIETAM QUARTZITE INTO SOLUTION OPENING.

Antietam Quartzite. Because this formation does not contain any carbonate it seems odd that a sinkhole would appear. Looking closer at the structure this thin belt of quartzite is a klippe bordered by a fault on the south side. This klippe is surrounded by the Vintage Dolomite with the nearest Antietam rocks being 0.5 miles north and east (Stose and Jonas, 1932, pl. 1; Wilshusen, 1979, pl. 1). Apparently the underlying Vintage Dolomite slumped forming a sinkhole not detectable on the surface due to the overlying quartzite. Through the freezing and thawing processes the quartzite and overlying soil became mobile. The extra weight of the horse and rider over this "arch" caused the material to collapse, filling the cavity once occupied by the Vintage rocks.

In summary it should be noted from this occurrence that sinkholes are not only restricted to carbonate formations on the surface, but may also occur in carbonate rocks overlain by other rock types. Engineers and contractors, among others, should be aware of this type of collapse even when the presence of sinkholes seems unlikely.

REFERENCES

Stose, George W., and Stose, A. I., 1933, *Geology and Mineral Resources of the Middletown Quadrangle, Pennsylvania*. U.S. Geologic Survey Bulletin 840.

Wilshusen, J. Peter, 1979, *Environmental Geology of the Greater York Area, York County, Pennsylvania*. Pennsylvania Geologic Survey, 4th series, Environmental Geological Report 6.

GEOLOGICAL RESEARCH IN PENNSYLVANIA

1980

INTRODUCTION

This publication is the twenty-third annual report on Geological Research and Publications in Pennsylvania. This is an attempt to list all current geologic research in Pennsylvania and *includes persons and projects other than those of the Pennsylvania Geological Survey*. Because of the large number of projects reported to us, we exercise editorial license to reduce the description of the research projects to fit our available space.

We have also attempted to determine an anticipated completion date (ACD) for each project. The anticipated completion date is the estimate of the date when the author will complete his report; additional time should be anticipated until the report is published. If you wish more information on a project described herein, please write directly to the author; most of these projects will *not* be published by the Pennsylvania Geological Survey inasmuch as most are not Survey staff projects.

The listings are grouped into major categories of research to facilitate your search for information on a particular subject. Reports published are listed alphabetically by author.

As with all compilations, there may be omissions; this is unintentional. Additional copies of this report may be obtained by writing to the Bureau of Topographic and Geologic Survey, Department of Environmental Resources, P.O. Box 2357, Harrisburg, Pennsylvania 17120.

AREAL GEOLOGY

ROBIN ABEL, The Pa. State Univ., and T. M. BERG and W. D. SEVON, Pa. Geol. Survey. Lithologic Map of Pennsylvania. This map will show (at a scale of 1:500,000) about 25 rock units across Pennsylvania and is being derived from the new state geologic map. ACD: Late 1981.

T. M. BERG, A. A. SOCOLOW, D. M. HOSKINS, A. R. GEYER, Pa. Geol. Survey, S. I. ROOT, Esso Products, W. E. EDMUNDS, Consultant, and D. B. MacLACHLAN, W. D. SEVON, A. D. GLOVER, and R. T. FAILL, Pa. Geol. Survey. Geologic Map of Pennsylvania (5th ed.). Compilation maps for the revision are on open file at the Survey's headquarters in Harrisburg. The map is in final drafting stages and is expected to go to press before the end of 1980.

M. J. BERGIN, U.S. Geol. Survey. Northern Anthracite Field, Pennsylvania. Geologic maps of the Kingston, Wilkes-Barre West, and Wilkes-Barre East 7½-minute quadrangles, and bedrock geologic maps of the anthracite-bearing rocks of the Kingston and Pittston 7½-minute quadrangles are currently in draft status. ACD: 1980.

R. T. FAILL, A. D. GLOVER, and J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Blandburg, Tipton, Altoona, and Bellwood Quads., Blair, Cambria, Centre, and Clearfield Cos., Pa. Mapping of bedrock units from Cambrian to Pennsylvanian in age, surficial units (alluvium), structures in the Valley and Ridge province and Appalachian Plateaus province, with discussion of the stratigraphy, structure, economic deposits, engineering properties, and environmental characteristics. ACD: 1980.

J. D. INNERS, Pa. Geol. Survey. Geology and Mineral Resources of the Allenwood and Milton Quads., Lycoming, Union, Northumberland, and Montour Cos., Pa. ACD: Dec. 1982.

P. T. LYTTLE, U.S. Geol. Survey. Newark 2-Degree Quad., N.J., Pa. Initial reconnaissance study of portions of the Pennsylvania Piedmont near the Huntingdon Valley-Cream Valley faults will get underway. Geologic maps of the Kutztown, Hamburg, and Slatedale 7½-minute quadrangles, Pa., and Blairstown 7½-minute quadrangle, N.J., will be compiled and submitted for publication. ACD: 1982.

D. B. MacLACHLAN, Pa. Geol. Survey. Geology and Mineral Resources of the Reading and Birdsboro Quads., Berks Co., Pa. ACD: July 1980.

H. W. SCHASSE, Pa. Geol. Survey. Geology and Anthracite Coal Resources of the Conyngham 7½′ Quad., Luzerne and Schuylkill Cos., Pa. ACD: Feb. 1981.

W. D. SEVON and T. M. BERG, Pa. Geol. Survey, L. D. SCHULTZ, Gilbert Assoc., and G. H. CROWL, Ohio Wesleyan Univ. Geology and Mineral Resources of Pike Co., Pa. ACD: Oct. 1, 1980.

A. M. THOMPSON, Univ. of Del. Bedrock Geology and Mapping in Northern Delaware and Adjacent Southeastern Pa. Continuation of mapping of bedrock geology and brittle structures in southern Chester and Delaware Counties, Pa., and northern New Castle County, Del.

J. H. WAY, Pa. Geol. Survey. Geology and Mineral Resources of the Washington and Millville Quads., Montour, Columbia, and Northumberland Cos., Pa. Geologic mapping of bedrock and surficial deposits, defining and sampling materials with possible economic potential, and describing environmental and engineering characteristics of all geologic units in the area. ACD: July 1981.

G. H. WOOD, JR., U.S. Geol. Survey. Southern Anthracite Field, Pa. If time is available, field work to map structure and stratigraphy of the Weatherly quadrangle, Pa., will be continued during FY 1980. Report preparation on the eastern part of the study area will continue. ACD: Continuing.

ECONOMIC GEOLOGY

T. M. BERG, A. D. GLOVER, C. H. DODGE, J. R. SHAULIS, and V. W. SKEMA, Pa. Geol. Survey. Coal Resources of Greene, Washington, Allegheny, Fayette, Westmoreland, Beaver, Butler, Cambria, Indiana, and Somerset Cos. Available data for coal-bearing strata in Greene and Washington Counties have been assembled and prepared for computer entry into the National Coal Resources Data System (NCRDS). Some information for Greene County has already been entered. Data for Allegheny, Fayette, and Westmoreland Counties are being assembled and prepared for entry, with ACD: Summer, 1980. Data for Beaver, Butler, Cambria, Indiana, and Somerset Counties will be assembled and prepared for computer entry by summer 1981. Coal reserve maps and tables, in addition to other derivative maps, will be produced when the output capabilities of NCRDS at the U.S. Geol. Survey in Reston, Va., are operational.

M. D. CARTER, U.S. Geol. Survey. National Coal Resources Data System. Information on coal resources and related subjects will continue to be collected and entered in computerized data system. Data are contributed to the system by the State Survey. This project has taken over the task of developing techniques for preparing geologic and resource maps that are computer generated. ACD: Continuing.

C. B. CECIL, U.S. Geol. Survey. Geology of Contaminants in Coal. Regional stratigraphic studies of the Upper Freeport Limestone to the Brush Creek Shale interval to determine the depositional history of the Upper Freeport coal will continue. Sampling programs will be initiated to test models that have been developed for the Upper Freeport coal bed; one sampling area will be the Pocahontas #3 coal bed in West Virginia, a low-sulfur low-ash coal; the other sampling site, not yet selected, will be in a high-sulfur, high-ash coal bed. ACD: Continuing.

WALLACE deWITT, JR., U.S. Geol. Survey. Land Classification—Oil and Gas, Eastern Region. The project will provide an evaluation of the oil and gas resources of selected wilderness and RARE II areas in the States of West Virginia, Virginia, Alabama, Kentucky, Pennsylvania, Illinois, and Mississippi, ACD: 1981.

WALLACE deWITT, JR., G. W. CLAYPOOL, T. S. DYMAN, A. G. HARRIS, L. D. HARRIS, J. W. HOSTERMAN, J. S. LEVENTHAL, J. B. ROEN, and J. W. SCHMOKER, U.S. Geol. Survey. Devonian Black Shale Study Program in the Appalachian Basin. The program is characterizing the potentially gas-productive dark Devonian shales and associated rocks in the Appalachian basin using stratigraphic, structural, mineralogic, paleontologic, geochemical, geophysical and hydrocarbon productivity data. ACD: 1981.

JANE EGGLESTON, Skelly and Loy. Extraction/Preparation Research and Development Needs for Anthracite. Skelly and Loy is formulating a comprehensive research and development plan for the DOE, that will promote enhanced recovery and expanded utilization of the extensive anthracite reserve base. ACD: May 31, 1980.

J. A. HARPER and C. D. LAUGHREY, Pa. Geol. Survey, and W. S. LYTLE, Univ. of Okla. Pennsylvania Oil and Gas Fields Project. Project is intended to update, standardize, and define the limits of all oil and gas fields in Pennsylvania. The final result will be a new oil and gas fields map showing major reservoirs as well as field and pool areas. ACD: 1981.

G. W. LENEY, U.S. Dept. of Energy, and BENDIX FIELD ENGINEERING CORPORATION. National Uranium Evaluation Program. Field work, preparation of preliminary folios, and recommendations on the assessment of uranium resources have been completed for Scranton, Williamsport, and Harrisburg 2° NTMS quadrangles, under the NURE program. Field work is in progress on the Newark quadrangle. ACD: 1983.

F. G. LESURE and A. E. GROSZ, U.S. Geol. Survey. Mineral Resource Evaluation of the Cornplanter RARE II, Pennsylvania. Project was scheduled to start spring 1980 but is delayed because of travel restrictions. ACD: Dec. 1981.

B. J. O'NEILL, JR., and J. H. BARNES, Pa. Geol. Survey, and K. J. LILES, U.S. Bur. of Mines. Properties and Uses of Shales and Clays in South-Central Pa. [Bedford, Blair, Centre, Fulton, Huntingdon, Juniata, Mifflin, Perry, Snyder, and Union Cos.]. The fourth in a series of projects to evaluate the potential of clay and shale occurrences for use in ceramic and non-ceramic applications, including collection of data on the mineralogy and major- and minor-oxide chemistry of the occurrences. ACD: 1980.

B. J. O'NEILL, JR., and FIELD MAPPING DIVISION, Pa. Geol. Survey, and U.S. BUREAU OF MINES. Investigations for High-Calcium Limestones in Pa. Objectives are: (1) to sample and analyze limestone units where information is lacking, incomplete, or widely scattered; (2) to map any newly discovered high-calcium limestone unit that has potential commercial applications, and (3) to synthesize the data into publications which will be useful guides to exploration targets. ACD: Continuous.

B. J. O'NEILL, Pa. Geol. Survey, and K. V. HOOVER, Pa. Dept. of Environmental Resources. Atlas of Pa.'s Mineral Resources, Part 2A, Clays and Shales of Pa. A compilation of data on physical testing, chemistry, and mineralogy of clay and shale samples, to aid in the identification of deposits with economic potential. ACD: 1981.

R. G. PIOTROWSKI, Pa. Geol. Survey. Medina-Tuscarora Stratigraphy and Gas Production (Subsurface, Western Pa.). Relationship of the regional stratigraphy of Medina-Tuscarora to known natural gas production to determine the geological constraints upon production and to evaluate future potential. ACD: June 1980.

G. H. P. POPPER and ROBERT BLAUVELT, Bendix Corp. Newark Quadrangle—National Uranium Resource Evaluation. ACD: Dec. 31, 1980.

A. W. ROSE and A. T. SMITH, The Pa. State Univ. Geology and Geochemistry of Cu-U Occurrences in the Catskill Fm. in Pa. About 50 Cu-U occurrences have been located and the geology and sedimentology described. Most occur in local reducing zones adjacent to permeable sandstones with evidence for deposition on a coastal plain influenced by tidal phenomena. ACD: Aug. 1980.

R. C. SMITH, II, and J. H. BARNES, Pa. Geol. Survey. Geologic and Mineralogic Interpretation of Gamma Ray Reconnaissance Data for the Reading Prong, Eastern Pa. [portions of Berks, Lehigh, Northampton, and Bucks Cos.]. To supplement aerial gamma ray data, collected as part of the NURE reconnaissance survey for the U.S. DOE, a ground survey is being made to locate anomalous areas. Representative samples from these areas will be collected for petrographic and trace element studies. ACD: June 1981.

TOM SPOHN and ALICE BLOUNT, Rutgers State Univ. at Newark. Mineralogy of the Residual Soils Which Overlie a Talc Deposit in the Stateline Serpentine, Pa. Samples of residuum obtained by hand auger along three traverses across the talc body and along one traverse not intersecting talc are being analyzed by X-ray diffraction and IR techniques. ACD: Fall 1980.

ENGINEERING GEOLOGY

PAUL CARNEY, Penn-Dixie Industries, Inc. Surface Drainage Patterns and Facies Changes Associated with Regression of the Vanport Sea [Worthington, Chicora, East Brady, and Kittanning Quads. in Butler and Armstrong Cos., Pa.] . Objective is to delineate erosional channels and structural changes relative to mine roof conditions. To date, a southwest meandering river drainage system has been partially mapped. Stratigraphic and engineering characteristics, transverse to drainage, are being studied. ACD: 1981.

W. E. DAVIES, JOHN POMEROY, PAUL RUANE, and ROBERT HACKMAN, U.S. Geol. Survey. Safe Mine Waste Disposal, Appalachians. The current phase of the project covers determination of slope stability, old and recent landslides, the cause of landslides and their stabilization. Mapping at 1:24,000 in Pennsylvania is complete and 7½-minute sheets are being prepared for open file. Printed 1:250,000 maps and a Professional Paper will be completed later. ACD: 1980 for Pa.

ENVIRONMENTAL GEOLOGY

R. L. DAVIS, WAYNE ROSENFELD, and CHARLES ROGAL, Univ. of Pitt. at Bradford. Land Use Capability in Ceres Twp., McKean Co., Pa. Project deals with mapping land use suitability for industrial, residential, recreational, and commercial development in Ceres Twp. ACD: Fall 1980.

N. K. FLINT and JAMES KRUSHIN, Univ. of Pitt. Geologic-Hazards and Slope-Stability Mapping in Deer Creek Watershed, Allegheny Co. ACD: 1981.

N. K. FLINT and RICHARD YEAGER, Univ. of Pitt. Geologic-Hazards and Slope-Stability Mapping in Little Sewickley Creek Watershed, Allegheny Co. ACD: 1981.

T. W. GARDNER and R. L. SLINGERLAND, The Pa. State Univ. The Impact of Surface Mining Activity on the Hydraulic Geometry and Related Morphometry of Fluvial Systems [Appalachian Plateau, western Pa.] . ACD: 1983.

A. R. GEYER, J. P. WILSHUSEN, and W. B. BARBER, Pa. Geol. Survey, and JESSE CRAFT, U.S. Bur. of Mines. Engineering Characteristics of the Rocks of Pa. (2nd ed.). Project covers geologic, engineering, and groundwater characteristics of each rock formation described on the 1980 State Geologic Map. Report is intended as a supplement to the new state geologic map. ACD: 1981.

J. S. POMEROY, U.S. Geol. Survey. Safe Mine Water Disposal. In 1979 progress has been primarily in report writing and processing of manuscript related to the 1977 storm-induced debris avalanching in Johnstown, land-sliding in the Greater Pittsburgh Region, and mass movement in Washington County, Pa. ACD: Field work completed for western Pa.

GENERAL GEOLOGY

W. M. JORDAN and R. M. BENSON, Millersville State Coll. Interrelationships of Geology and Industry in Eastern Pa. A study in business history and the history of science, with special emphasis on the Second Geological Survey of Pennsylvania and the exploitation of anthracite. ACD: 1982.

J. P. WILSHUSEN, Pa. Geol. Survey. Geology of the Appalachian Trail in Pa. [SE Pa.] . A description of characteristics of each physiographic section with detailed, illustrated accounts of points of interest along the trail route. Sketch maps with geologic cross sections and descriptions at specific points are keyed to a geologic map of the trail. ACD: Dec. 1980.

T. O. WRIGHT, Allegheny Coll., G. C. STEPHENS, George Washington Univ., and L. B. PLATT, Bryn Mawr Coll. Structure and Stratigraphy of the Martinsburg and Reedsville Formations in the Central Appalachians. The goals of this project are to develop a biostratigraphy, based on graptolites, for these rocks, to investigate structural relationships, including cleavage development, and to determine the environment of deposition and geologic history in some detail. ACD: 2 years.

[illegible]

A. W. ROSE, CHRISTY BELL, P. M. TOLE, and SIMON PIRC, The Pa. State Univ. Regional and Local Uranium Anomalies in Rocks Around Sandstone Uranium Deposits in the Catskill Formation, Eastern Pa. Sandstones and shales of the mineralized Duncannon

Member of the Catskill Fm. near Jim Thorpe are weakly anomalous in uranium and thorium and uranium in zircons. The oxidized paleoaquifer near the Penn Haven Junction U occurrence is distinctly anomalous in uranium. ACD: May 1980.

A. W. ROSE and JOSEPH McNALLY, The Pa. State Univ. Use of Groundwaters in Exploration for Lead and Zinc in Carbonate Rocks of Pa. A comprehensive study of ground-water chemistry near known lead and zinc deposits shows distinct anomalies in zinc, lead and other components. Techniques for recognition of weak anomalies are being tested. ACD: Aug. 1980.

GEOMORPHOLOGY

D. D. BRAUN, Bloomsburg State Coll., and J. D. INNERS, Pa. Geol. Survey. Seismic Investigations of the Orangeville "Umlaufberg" and Tenmile Run Valley, Columbia Co., Pa. ACD: Spring 1981.

T. W. GARDNER, The Pa. State Univ. The Effects of 19th Century Logging Operations and Deforestation on Sediment Yields on Small Drainage Basins [Centre, Union, and Blair Cos.] . ACD: 1983.

T. W. GARDNER, The Pa. State Univ. Morphology and Evolution of Colluvial Slopes in Central Pa. ACD: 1983.

NOEL POTTER, JR., Dickinson Coll. Distribution and Origin of Colluvium and Gravel, North Flank of South Mountain, Cumberland Co. ACD: Continuing.

W. D. SEVON, Pa. Geol. Survey. The Harrisburg Peneplane: Age and Reality [SE Pa.] . Distribution of Tuscarora quartzite boulders on dissected landscape developed on Martinsburg shale south of Blue Mountain in southeastern Pennsylvania gives credence to the reality of the Harrisburg Peneplane and allows an estimate of its age.

E. L. WHITE and W. B. WHITE, The Pa. State Univ. Geomorphology of the Appalachian Karst [N.Y. to Ala.] . Quantitative landform description and interpretation of landform sculpturing processes in carbonate terrains. Study of the surface landform patterns and cave distribution relationships in the Valley and Ridge province of Pennsylvania now underway. ACD: Will never be complete.

W. B. WHITE, The Pa. State Univ. Caves of Pa. Complete descriptions and maps are being compiled for all caves in Pennsylvania. Data for Centre County were completed and data for Mifflin County are largely complete this year. ACD: 1980.

GEOPHYSICS

W. H. DIMENT, U.S. Geol. Survey. Seismotectonics of the Northeastern U.S. Studies of deep geologic conditions as revealed by analyses of gravity, magnetic, heat-flow, seismic, and drilling data will continue in the northeastern states. A gravity map of the State of Pennsylvania will be prepared during FY 1980. Gravity and magnetic data from the Appalachian region will be analyzed to determine the deep structural features of that area. The relationship of eastern U.S. seismicity and seismogenic structures will also be analyzed. ACD: 1983.

B. F. HOWELL, JR., The Pa. State Univ. Seismic Hazard Studies in the U.S. Methods of predicting the probability of occurrence of earthquakes of various sizes in any year are being investigated for all and various parts of the United States and other areas. ACD: 1982.

ROB VAN DER VOO and P. BROWN, Univ. of Mich. Paleomagnetism of the Wilmington, Del., district and adjacent Piedmont areas. ACD: July 1982.

GLACIAL GEOLOGY

E. B. EVENSON and J. F. P. COTTER, Lehigh Univ., LES SIRKIN, Adelphia Univ., and W. D. SEVON, Pa. Geol. Survey. Wisconsin Deglaciation Chronology of NE Pa. and NW N.J. The project will attempt to establish a radiocarbon controlled deglaciation chronology by dating organic matter recovered from bogs and lakes in the study area. Palynologic studies will enable verification of the antiquity of dated samples and modeling of post-glacial vegetation changes. NSF Grant EAR-78-14778. ACD: June 1981.

E. B. EVENSON and JACK RIDGE, Lehigh Univ., and CARL KOTEFF, U.S. Geol. Survey. Glacial Geology of the Great Valley Near the Terminal Moraine in Northampton Co., Pa., and Warron Co., N.J. [NE Pa. and NW N.J.] . Morphologic sequence mapping of the Oxford, Pequest and Paulins Kill Valleys from the "Terminal Moraine" north has been completed. Ice margin positions marked by deltas and heads of outwash support deglaciation by stagnation zone retreat. ACD: Midsummer 1980.

HYDROLOGY

K. M. LONG and J. P. FAWLEY, Westminster Coll. Hydrology and Biology of Harlansburg Cave. Project also includes mapping this extensive maze cave. ACD: Sept. 1980.

ANTHONY SEGZDA and JOHN TOMIKEL, California State Coll. Seasonal Variations in the Discharge of Pike Run. This is a Master's project for a graduate student. ACD: Aug. 1980.

R. A. SLOTO and DREW DAVIS, U.S. Geol. Survey. A Stormwater Management Model for the West Branch, Brandywine Creek Watershed, Chester Co., Pa. Three distributed routing rainfall-runoff models will be developed for the West Branch, Brandywine Creek. ACD: Sept. 1980.

R. A. SLOTO and DREW DAVIS, U.S. Geol. Survey. Effect of Urbanization on the Quantity and Quality of Ground Water and Low Streamflow in Warminster Twp., Bucks Co., Pa. ACD: Sept. 1981.

L. E. TAYLOR and D. W. ROYER, Pa. Geol. Survey. Summary Groundwater Resources of Adams Co., Pa. Description and inventory of the groundwater resources of Adams County. A geologic map at scale of 1:50,000 will be included along with tables of well records and selected chemical analyses. ACD: June 1980.

MICHAEL TERRETTI and JOHN TOMIKEL, California State Coll. Seasonal Changes in Acid Mine Drainage [small streams in SW Pa.] . This is a Master's project; the results will not be published. ACD: July-Aug. 1980.

D. W. WILLIAMS, J. D. STONER, and others, U.S. Geol. Survey, and C. H. DODGE, Pa. Geol. Survey. Hydrology of Coal Areas, Greene Co., Pa. Effect of coal development on quantity and quality of surface and ground waters will be analyzed and predicted. Surface geology compilation is nearly completed. ACD: Mar. 1982.

C. R. WOOD and G. N. PAULACHOK, U.S. Geol. Survey. Groundwater Quality and Flow in the Coastal Plain Aquifer, Phila. Area, Pa. ACD: Sept. 1981.

MINERALOGY

J. H. BARNES and R. C. SMITH, II, Pa. Geol. Survey. List of Verified Mineral Species in Pa. A continuously updated, annotated list of thoroughly identified and documented mineral species occurring in Pennsylvania is maintained in computer storage. Thirty-one species have been added since the *Mineralogy of Pennsylvania 1966-1975* was published. Revisions will be published bi-annually in *Pennsylvania Geology*. ACD: Continuing.

G. E. EDDY, Waynesburg Coll. Paleontology and Paleoecology of the Ames Limestone in Western Pa., Northern W. Va., and Eastern Ohio. ACD: Fall 1981.

B. L. FAULKNER, SUNY at Stony Brook. Morphological Changes in *Mucrospirifer mucronatus* (Brachiopoda: Spiriferida) Within Numerically Expanding Populations from the Mahantango Shales (Middle Devonian, Central Pa.) [Perry Co.]. ACD: Aug. 1980.

H. R. FELDMAN, Am. Museum of Nat. Hist., and DICK LINDEMANN, Skidmore Coll. Community Ecology of the Onondaga Limestone and Equivalents in Pa. (e.g., Buttermilk Falls). ACD: 1982-1983.

A. G. HARRIS, U.S. Geol. Survey. Conodont Succession Across Lower/Middle Ordovician Boundary, Central Appalachians. Field investigations will take place in the Valley and Ridge province of Pa., W.Va., Va., and Md. during FY 1980. Outcrop sections will be measured and described and samples collected for conodont analysis. Lower Ordovician strata in Pa. and N.J. will also be sampled for conodont analysis. A preliminary report on collections from measured sections that were analyzed earlier will be prepared. ACD: Continuing.

D. M. HOSKINS and J. D. INNERS, Pa. Geol. Survey. Fossil Collecting in Pa. (2nd ed.). Limited progress. ACD: Oct. 1980.

W. F. KLOSE, II, Paleontological Research Inst. Contributions to the Pennsylvanian Age Flora and Fauna of the Anthracite and Semi-Anthracite Coal Fields of NE Pa. Collection of Pennsylvanian age flora and fauna with deposition of prepared specimens in the William Penn Memorial Museum, Harrisburg. All specimens collected to date prepared and transferred. ACD: Ongoing.

JOHN OLEKSYSHN, Boston Univ., Emeritus. Fossil Plants from The Anthracite Fields of Eastern Pa. and Their Stratigraphic Value. ACD: Fall 1981.

W. A. OLIVER, JR., and J. M. BERDAN, U.S. Geol. Survey. Biostratigraphy of Late Silurian-Early Devonian of Central Appalachians

[N.Y., Pa., Md., Va., W.Va.]. Corals and ostracodes of the Keyser and Helderberg units are being studied both systematically and biostratigraphically. ACD: 1984-1985.

ALFRED TRAVERSE and V. F. MUTTI, The Pa. State Univ. Palynological Studies in the Middle and Late Devonian of Central Pa. [Huntingdon, Centre, Blair, and Mifflin Cos.]. ACD: Indefinite.

ALFRED TRAVERSE, The Pa. State Univ., and P. K. STROTHER, Harvard Univ. An Investigation of Lower Silurian Land Plants in North-Central U.S. [Pa., N.Y., Me., N.J., northern Va. (Appalachians)]. ACD: 1982.

SEDIMENTOLOGY

EDWARD COTTER, Bucknell Univ. Depositional Environments of the Tuscarora Formation in the Valley and Ridge of Pa. ACD: June 1981.

S. B. KATZ, SUNY at Stony Brook. A Chemical and Hydrologic Model for the Lockatong Fm. (Triassic) of N.J. and eastern Pa. The distribution and morphology of evaporites and sedimentary textures in a closed basin is dependent upon many parameters, such as brine chemistry and ground water hydrology. Models exist for modern closed basins, however, these have not been applied to ancient deposits. To date seven lithotypes, including possible paleosoil textures have been identified. ACD: Aug. 31, 1980.

A. M. THOMPSON and D. C. GOLIKE, Univ. of Del. Sedimentology of Sandstones in Middle Reedsville Formation, Central Pa. Master's thesis project on identification of sandstone and limestone types of contrasting origins. Origins signify that new models of Ordovician flysch basin may be possible. ACD: May 1980.

M. A. THOMSEN and W. D. MARTIN, Miami Univ. Petrology of the Mudstones and Shales of the Dunkard Group (Upper Pennsylvanian and Permian) of Pa. and W.Va. [Dunkard basin—Washington and Greene Cos., Pa.]. This research is directed toward a petrologic investigation of the mudstones and shales of the northern Dunkard Basin. The main objective will be to determine the mineral composition of the various size fractions. Clay polytypes will be studied to determine detrital from authigenic origins. ACD: Aug.-Sept. 1980.

K. D. ABEL, Pa. Geol. Survey, and LOUIS HEYMAN, Coastal States Gas Corp. Oriskany Sandstone in the Subsurface of Pa. The following maps, based on subsurface correlations, will be published: 1. Ridgeley isopach and sub-Onondaga subcrop map; 2. Sandstone thickness map; 3. Oriskany production map; and 4. Drilling depth map. ACD: July 1980.

T. M. BERG, Pa. Geol. Survey, and W. E. EDMUNDS, Consultant. The Huntley Mountain Formation: Catskill to Burgoon Transition in North-Central Pa. This newly defined formation has its type section at Huntley Mountain near Waterville, Pa. ACD: 1980.

A. D. GLOVER, C. H. DODGE, V. W. SKEMA, and J. R. SHAULIS, Pa. Geol. Survey. TASIC (Temporarily Available Stratigraphic Information Collection). This project is a continuing program for recording stratigraphic data on active coal and clay strip mines while exposures are available. The ongoing project is designed to provide data for future mapping and regional mineral resource evaluation. ACD: Continuing program; volume 4, 1981.

S. L. McCANDLESS, Indiana Univ. of Pa. Subsurface Interpretation of the Environment of Deposition and Paleogeography of the Upper Devonian "Bradford Sands" in the Punxsutawney 15-Minute Quad., Pa. ACD: Dec. 1980.

C. L. PETERMAN, Indiana Univ. of Pa. Subsurface Interpretation of Environment of Deposition and Paleogeography of the Upper Devonian Bradford Sands in NW Indiana Co., Pa. ACD: Dec. 1980.

J. B. ROEN, U.S. Geol. Survey. Stratigraphy of the Devonian Black Shale in the Appalachian Basin. Project will continue to gather and analyze data and to prepare reports and maps that establish a regional stratigraphic framework and delineate the areal extent, thickness, and structure of the Devonian black shales and related rocks. Final goal of the project will be the complete characterization and determination of the hydrocarbon resource potential of the Devonian black shales. ACD: Continuing.

STRUCTURAL GEOLOGY

PING-FAN CHEN, W. Va. Geol. and Economic Survey. Lower Paleozoic Stratigraphy, Tectonics, Paleogeography, and Oil/Gas Possibilities in the Central Appalachians, Part 3, Tectonics. ACD: Manuscript completed.

A. A. DRAKE, JR., U.S. Geol. Survey. Central Appalachian Continental Margin Transect (U.S. Geodynamics Transects Program) [corridor from Ithaca, N.Y., thru eastern Pa. and north-central N.J. to Atlantic City to central Baltimore Canyon Trough]. Study is to assess the state of understanding of the structure and history of this transitional area from the North American craton and Atlantic oceanic lithosphere, to identify major problems, and to recommend programs for their solution. ACD: Late summer 1981.

A. A. DRAKE, JR., and A. E. NELSON, U.S. Geol. Survey, and L. M. HALL, Univ. of Mass. Basement-Cover Relation Map of the Appalachian Orogen (part of IGCP Project 27, Caledonian orogen) [Appalachian-wide, includes Reading Prong, Blue Ridge, and Piedmont of Pa.]. This map will show rocks which were basement during the Caledonian orogenic cycle and their relation to cover. Their age, date of last major tectonism, metamorphic state, and tectonic status (autochthonous, parautochthonous, allochthonous, or highly allochthonous) will be depicted. ACD: Late summer 1981.

R. T. FAILL, Pa. Geol. Survey. Tectonic Map of Pa. Map will display: 1) location, extent, and name of each of the major folds and faults; 2) prominent joint orientations; 3) contours on top of basement; 4) outcrop trace of Old Port Formation, and important angular unconformities; 5) structure contours on top of Onondaga in western and north-central Pennsylvania; 6) igneous bodies; 7) tectonic and metamorphic boundaries; 8) radiometric dates with locations; and 9) earthquake epicenters. ACD: June 30, 1981.

L. D. HARRIS, U.S. Geol. Survey. Structural Studies of the Devonian Shale in the Appalachian Basin. Field investigations have been completed, and FY 1980 will focus on the completion of reports on all structural features that may have produced natural subsurface fracturing and, thus, would allow for gas production from the Devonian black shale sequence. ACD: 1981.

R. P. NICKELSEN, Bucknell Univ. Structural Studies in the Valley and Ridge Province. Studies include sequence of structural stages, finite strain of 2- and 3-dimensional objects in suitable formations, strain partitioning, strain discontinuities, temperature of deformation stages as determined from fluid inclusion microthermometry [Valley and Ridge of central and south-central Pa.]. ACD: 1982.

JOHN SUPPE, Princeton Univ. Structural Cross Sections of Selected Structures in Pa. Valley and Ridge. Part of larger project involving similar structures in Taiwan and southern Appalachians. ACD: 1982.

A. M. THOMPSON, Univ. of Del. Remote Sensing Analysis of Tectonic Regime in Eastern Piedmont, Pa., Del., and N.J. Computer-assisted analysis of modern tectonic regime and seismicity controls in eastern Pennsylvania, northern Delaware, and northern New Jersey. ACD: 1981.

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LIME IN PENNSYLVANIA

The U.S. Bureau of Mines reports that at the end of 1978 there were 155 lime producing plants in the U.S. Pennsylvania ranked 4th in the nation with 10 plants. One Pennsylvania lime producer, the Annville plant of Bethlehem Steel Corporation in Lebanon County ranked as the 6th largest individual lime producer in the country.

Following is the complete list of Pennsylvania lime producers:

Company	*Plant Name*	*County*
J. E. Baker Co. Box 1189 York, PA 17405	York	York
Bethlehem Steel Corp. Martin Tower Bethlehem, PA 18016	Hanover Annville	Adams Lebanon
G. & W. H. Corson, Inc. Stenton Ave. and Joshua Rd. Plymouth Meeting, PA 19462	Plymouth Meeting	Montgomery

Domtar Industries, Inc., Lime Div. Box 118 Bellefonte, PA 16823	Bellefonte	Centre
Honey Creek Lime Co. Reedsville, PA 17084	Reedsville	Mifflin
Marblehead Lime Co. 300 W. Washington St. Chicago, IL 60606	Pleasant Gap	Centre
Mercer Lime & Stone Co. 525 William Penn Pl. Pittsburgh, PA 15219	Branchton	Butler
Warner Co. Yellow Springs Rd. Devault, PA 19432	Bellefonte Cedar Hollow	Centre Chester

SURVEY ANNOUNCEMENTS

TWO LONG TIME EMPLOYEES RETIRE

CHARLES UPDEGRAFF

Charles H. Updegraff joined the Department of Mines and Minerals in 1967 as an Oil and Gas Inspector in the Division of Oil and Gas. One year later he assumed the duties of Petroleum Engineer. One of his duties included mapping and taking samples of fluids flowing from abandoned oil or gas wells located along various watersheds where the streams were being polluted from these discharges. Abatement procedures were developed from these studies and wells were plugged on three watersheds under Division supervision. Other duties included maintaining compliance with the Underground Gas Storage and Oil and Gas Conservation Acts.

In May 1977 he was appointed Acting Chief of the Division, then under the Bureau of Land Protection, and continued as Acting Chief when the Division was transferred to the Survey. In June 1979 he was appointed as Geologist Supervisor to implement the Division's role in administering the Federal Natural Gas Policy Act. This was a completely new and complex program and Charlie's attention and dedication made it possible to get the program going to the satisfaction of all concerned.

Charles Updegraff was born in Latexo, Texas, reared in Williamsport, Pennsylvania and graduated from Penn State in 1938 with a B.S. degree in Geology. He is a registered professional engineer. He has been associated with the oil and gas industry since his graduation from Penn State, mainly as an independent until he joined the Commonwealth. He has represented Pennsylvania on numerous committees of the Interstate Oil Compact Commission.

Charlie and his wife Elsye live in Coudersport, Pennsylvania, where one daughter and one son also reside. His other daughter resides in Hershey, Pennsylvania. You probably can find Charlie in his garden or on the golf course upon his retirement.

The Commonwealth and the oil and gas industry have greatly benefited from Charlie's dedicated services. We wish him and his family many, many years of healthy, happy retirement.

JOHN NAVOLA

On May 7, 1980, John P. Navola retired from the Division of Oil and Gas Regulation of the Survey where he had been an Administrative Officer. John began his career with the Commonwealth in the Department of Mines and Minerals, which later became part of the Department of Environmental Resources. He brought many years of experience in the coal mining industry to the Division and was primarily responsible for instituting the office procedures for implementation of the Oil and Gas Laws in Pennsylvania.

John Navola has provided the Department with outstanding and conscientious service over the past 23 years and will certainly be missed. We wish him many long years of good health and happiness.

GEOLOGIST JOINS SURVEY

THOMAS A. McELROY joined the Environmental Geology Division of the Survey July 31 as a hydrogeologist. He will be compiling groundwater reports of surface-mined areas of Pennsylvania. At the conclusion of a four-year hitch in the Air Force, which included a year in Vietnam, Tom enrolled at SUNY Binghamton, where he completed his studies for a B.A. in geology in 1976. After a year and a half of working on a seismic crew in Colorado, Wyoming and Idaho, he entered the Master's program at the University of Massachusetts at Amherst, where he studied hydrogeology, geophysics, and glacial geology. He will receive his M.S. from the University of Massachusetts upon completion of his thesis, "Hydrogeology of Fish Hatcheries in Western Massachusetts."

Continued from State Geologist, pg. 1...

assessment of the project impacts on the geology and vice versa. But we cannot be oblivious to the overall and net impacts of a project. Having long ago moved beyond the assessment of only biological and physical impacts, the environmental impact assessment calls for broader perspectives than were originally involved in EIS's. We must now fairly evaluate the positive and negative aspects, keeping in mind not only the protection of our physical and biological elements, but the economic, social, and military strength of our community and our nation in a highly competitive and frequently hostile world. The environmental impact assessment never was simple, nor should it be; the strength and survival of our society calls for the broadest possible assessment that will enable decision makers to do what is best for our state and our nation.

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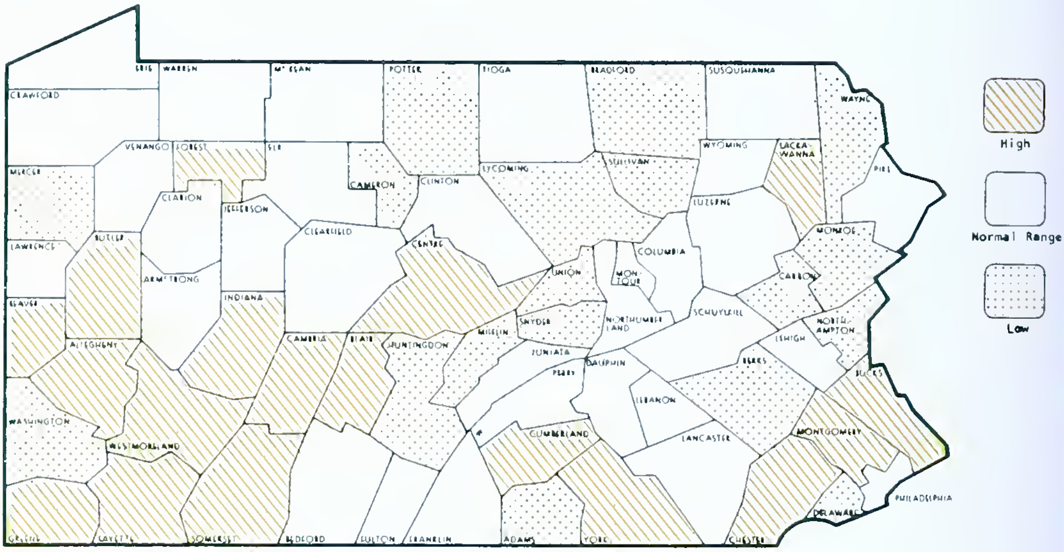

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THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 11/5

COMMONWEALTH OF PENNSYLVANIA
Richard L. Thornburgh, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Clifford L. Jones, Secretary

TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Typical costly and hazardous landslide development in the Pittsburgh area. Photo courtesy of William R. Adams, Jr. of the Allegheny County Geotechnical Center.

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OCTOBER 1980

FROM THE DESK OF THE STATE GEOLOGIST...

NOT ENOUGH RESPECT FOR PENNSYLVANIA'S OIL AND GAS

Even as there has been proper recognition of the huge reserves of anthracite and bituminous coal remaining to be developed in Pennsylvania, another pair of valuable energy resources in Pennsylvania has failed to receive the public recognition they properly deserve.

Although the story of oil and gas extraction actually began in Pennsylvania in 1859, there is a general lack of awareness that our state's oil and gas production is still going strong and is actually increasing. The final 1979 oil and gas production and exploration statistics have been assembled and released by the Pennsylvania Geological Survey. These show 2.8 million barrels of oil and 96.3 million cubic feet of natural gas taken out of the ground of Pennsylvania in 1979. Even more important is the increase in both our oil and gas reserves during the year. This is a tribute to the industry's confidence in Pennsylvania's oil and gas potential and to the resulting increase in exploration and drilling. The 1941 new oil and gas wells drilled during 1979 represents an 11 percent increase over the prior year. And in 1980 we have already recorded a record number of new drilling permits, which attests to the continuing enthusiasm and activity by the oil and gas industry.

It is, of course, certain that a major incentive for increased drilling has been the rise in both oil and natural gas prices. But there is more than that to explain the growing interest in developing Pennsylvania's oil and gas resources. The fact is that despite the history of 121 years of oil and gas development and hundreds of thousands of wells which have been drilled over that period in Pennsylvania, there remains a vast volume of deeper rock formations which have not been penetrated or tested by the shallow wells drilled to date. Dr. Dana Kelley noted in 1970 that 83 percent of Pennsylvania's potential petroleum-bearing rocks remain untested. Therein lies the challenge and the promise of our future oil and gas production.

It is good to see that the new statistics of increased exploration and drilling show that the oil and gas industry is rising to the challenge of locating Pennsylvania's deeply buried oil and gas resources. And just as we take pride and hope in the existence of the vast coal resources with which we have been blessed, so too should we look with enthusiasm to the oil and gas resources which await to be developed within the boundaries of the Commonwealth. Not only every ton of coal, but also every barrel of oil and every cubic foot of natural gas which we produce within our state is a contribution to our self-sufficiency, our economy, and our security.

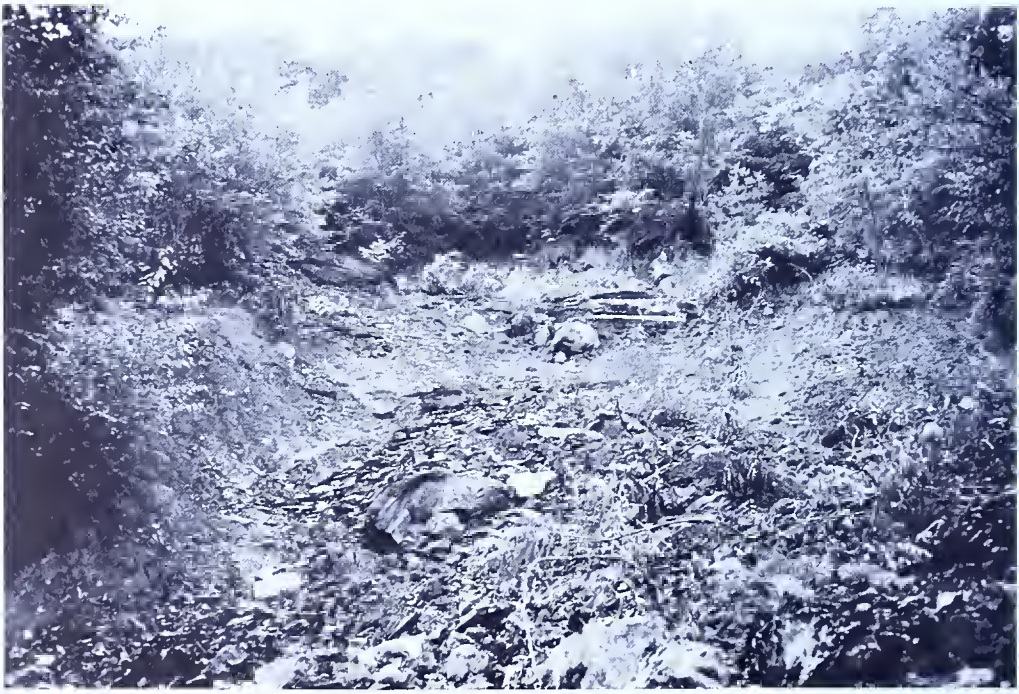
Arthur A. Socolow

RECENT STORM–INDUCED LANDSLIDES, EAST BRADY AREA, PENNSYLVANIA

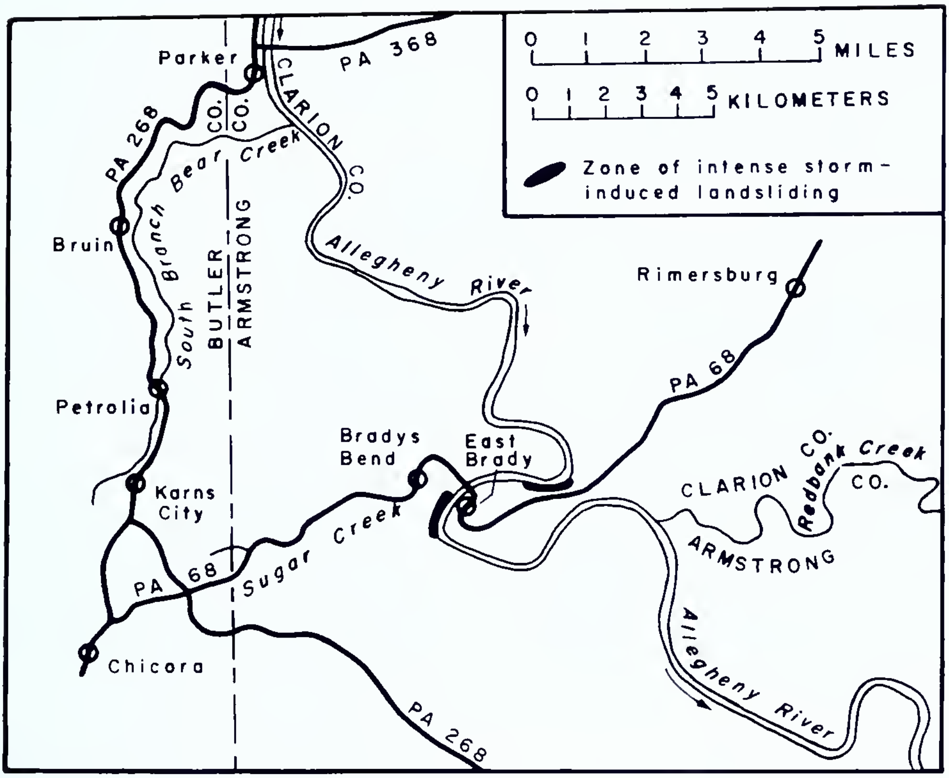
John S. Pomeroy, U.S. Geological Survey

On the night of August 14-15, 1980, torrential rains drenched the East Brady - Brady's Bend area, which lies about 50 miles northeast of Pittsburgh. The storm intensity (a reported 4-inch rainfall during a 4-hour period) more than exceeded the infiltration capability of the soil and resulted in heavy surface runoff, subsequent flooding, and landsliding.

Nine lives were lost in the flooding along Sugar Creek, which empties into the Allegheny River opposite East Brady. The small community of Brady's Bend including PA Highway 68 was devastated by the rampaging waters of Sugar Creek. The South Branch of



Head of debris avalanche formed during East Brady storm



Bear Creek, which flows through Karns City, Petrolia, and Bruin, also overran its banks but did not cause as much destruction. Nearly $50 million damage was done in an area involving parts of Armstrong, Butler, and Clarion Counties. A 3-inch rainfall on the same general area 6 days after the storm fortunately caused no further damage.

Although several small landslides took place on slopes bordering Sugar Creek and its tributaries, most slope movements were in two major areas, each about 1 mile wide, along the Allegheny River near East Brady. One area is the east-facing slope along the west side of the Allegheny River opposite East Brady. The other is the north-facing slope on the south side of the river east of East Brady.

On the east-facing slope, landslides damaged at least two vacant trailer-mobile homes. A car was swept out into the river by a slide, and another car was damaged. Fortunately, no lives were lost because of landsliding. Eyewitness accounts established that the sliding took place *during* the storm.

The north-facing slope east of East Brady is devoid of any settlement. However, an unimproved road along the base of the slope was severely damaged.

At least 50 landslides were recognized on these two slopes and adjacent areas. A number of smaller scars, undoubtedly, are hidden by the forest canopy. Many of them will become apparent by early or mid-November after the leaves have fallen. The long, narrow scars on the slopes near East Brady are caused by the debris avalanches, which are rapid downslope sliding and flowage of water-saturated soil and rock debris. Scores of debris avalanches formed in the Johnstown area during the more intense storm of July 19-20, 1977. Other landslide types that originated during the East Brady storm include slumps and debris slides.

Four conditions are prerequisite for extensive slope failures in western Pennsylvania—steep hillsides, presence of both sandy and clayey weathered rock and soil debris, intensive rainfall, and an abnormally high total precipitation during the weeks preceding the storm. All these conditions were met in the East Brady area.

Scars, that in many places expose bedrock in these areas, will be seen for many years. Possibly several decades will pass before the scars "heal," and soil and vegetation once again cover the slide paths.

scholarship assistance available for minority geoscience majors

The American Geological Institute's scholarship program for geoscience majors of minority groups expects to offer scholarship aid for the academic year 1981-1982. Approximately 50 scholarships, ranging in value from $250 to $1,500 per academic year, will be awarded. Those eligible to apply for the scholarships are geoscience majors, currently enrolled in accredited institutions as either undergraduate or graduate students, who are U.S. citizens and members of designated minority groups. The term "geoscience" is used to include study in the fields of geology, geophysics, geochemistry, hydrology, meteorology, oceanography, and space science. The eligible minority groups include American Blacks, Native Americans, and Hispanics.

Requests for application materials and nominations for scholarships should be addressed to Dr. William H. Matthews, III, Director of Education, American Geological Institute, Box 10031, Lamar University Station, Beaumont, Texas 77710. The deadline for filing applications is February 1, 1981.

COSTS OF LANDSLIDE DAMAGE IN ALLEGHENY COUNTY, PENNSYLVANIA

This article is excerpted from U.S.G.S. Circular 832, "Estimating the Costs of Landslide Damage in the United States" by Robert W. Fleming and Fred A. Taylor, 1980.

Costs of landslide damage have been documented for several areas in the Western United States, but few studies have been completed of losses in the East. William R. Adams, Jr., of the Allegheny County Geotechnical Center, conducted a preliminary study of the costs of landslide losses in Allegheny County. His study revealed that large losses occur annually and that a more complete accounting of landslide damages could be obtained through interviews with some of the affected agencies and individuals.

Allegheny County is a highly urbanized county in western Pennsylvania, and Pittsburgh is its principal city. The county has 1.6 million inhabitants within its 728-mile area. Landslides have been a continuing problem for many years. The areas susceptible to landsliding in Allegheny County have been mapped by Pomeroy and Davies (1975).

This is a summary of the estimated costs of landslide damage in Allegheny County for the 7-year period of 1970-76. All costs are in terms of dollars expended during a given year, and no adjustments have been made for inflation. Information reported here was obtained from interviews conducted in Allegheny County during the week of August 8-12, 1977, from Mr. Adams, and with followup correspondence. Only a small percentage of all the potential sources of information was contacted. Undoubtedly a more comprehensive survey would reveal additional losses. Public sources that were contacted included federal, state, county, and city agencies such as road departments, planning departments, environmental departments, and assessors; utility companies; sewage disposal agencies; and schools. In most organizations, only one individual was contacted. A listing of organizations that were contacted or that contributed information is in table 1.

TABLE 1 - Sources of information contacted on costs of landslide damage in Allegheny County, Pa.

Source
City of Pittsburgh:
City Parks
Department of Lands and Buildings.
Department of Public Works
District Permit Engineer
Personal property Tax Office
Pittsburgh Public School System
Planning Department
Police Department
Statistical Information
Water Department
Allegheny County and Regional Offices:
Allegheny County Geotechnical Center.
Allegheny County League of Municipalities.
County Parks
Intermediate Unit (schools)
Police Disaster Office
Public Works Planning and Development.
Regional Parks
Non-county agency:
Allegheny County Sanitary Authority.
Commonwealth of Pennsylvania:
Bureau of Topographic and Geologic Survey.
Department of Environmental Resources.
Department of Transportation (PennDOT).
National Guard
Property Tax Assistance Bureau.
Solid Waste Management
State Forestry
Water Quality
Federal government:
Corps of Engineers
Soil Conservation Service
Private:
Consulting engineering and geology firms.
Utility companies

The principal problem in obtaining data on costs of damage from landslides in Allegheny County is the very large number of sources that might have information. Only the most obvious sources could be contacted in the time available. There are 129 municipalities in Allegheny County. Some of these have offices that maintain records of costs for repair of landslide damage; others contract such work through private consulting companies and may have an incomplete account of costs. At least 200 utility companies exist in the county (table 2); added to these are several railroads, various river transportation authorities, and numerous commercial concerns. Other organizations that might have information but were not contacted are the Allegheny County Assessor's Office, Southwest Pennsylvania Regional Planning Commission, Pennsylvania Department of Mine Subsidence, and various other county and city of Pittsburgh offices. Additional federal and private costs might have been obtained, particularly for 1972, from the SBA and the Federal Disaster Assistance Administration.

TABLE 2 - Types and number of utility companies in Allegheny County, Pa.

(W. J. Adams, Jr., written commun., 1978)

Type	Number
Telephone companies	8
Gas companies	11
Electrical companies	3
Heating transmission companies	1
Petroleum transmission companies	11
Cable television companies	15
Oil companies	30
Water companies	58
Sewerage companies	63
Total	200

The willingness or ability to provide data varied from organization to organization. Some sources could give a fairly complete account of expenditures for landslide damage, whereas others could give only a yearly estimate. Some consultants were reluctant to release information out of concern for the confidentiality of their clients.

Most of the costs data in this report are for the calendar years 1970-76. However, because some agencies use different recording periods—fiscal year or seasonal year—some costs may not have occurred in the calendar year to which they are ascribed. This discrepancy probably does not materially affect the total cost estimates.

Two categories of costs are reported: public and private. Most of the public landslide costs is the direct expense of repairing and restoring roads. This includes expenses readily attributed to specific large landslides and an educated guess for smaller slides, as these costs are included within budgets for routine road maintenance and repair. Public costs also include damage to municipally owned utilities and sidewalks and to other publicly owned facilities. Some public costs could not be classified as federal, state, or county and were grouped as "municipal and other public funds." Items under this heading include expenses jointly funded by several levels of government, expenses of schools and parks, and those for several landslides believed to have resulted in local expenses but for which

TABLE 3 - Costs of damage due to landslides in Allegheny County, Pa. (1970-76)

Source	1970	1971	1972	1973	1974	1975	1976	7-year total	Yearly Average	Annu cap
Public:										
Federal----------	$3,000	$3,000	$903,000	$3,000	$3,000	$3,000	$3,000	$921,000	$132,000	$
State------------	no data	319,000	1,801,000	703,000	290,000	1,768,000	952,000	5,833,000	833,000	
County-----------	no data	10,000	122,000	10,000	20,000	2,000	2,000	166,000	24,000	
Municipal and other public funds---------	878,000	393,000	600,000	466,000	705,000	793,000	450,000	4,285,000	612,000	
Subtotal---	881,000	725,000	3,426,000	1,182,000	1,018,000	2,566,000	1,407,000	11,205,000	1,601,000	
Private----------	582,000	582,000	582,000	621,000	590,000	574,000	554,000	4,085,000	584,000	
Total-----	$1,463,000	1,307,000	4,008,000	1,803,000	1,608,000	3,140,000	1,961,000	15,290,000	2,185,000 [1]($4,000,000)	(
Percent of total that is private	40	45	15	34	37	18	28	27	27	--

[1] Because only a few of the more obvious sources of costs-of-damage information were contacted, the authors think tha the annual cost exceeds $4 million.

documentation was incomplete. Private costs are expenses to individuals and nonpublic groups.

Table 3 shows amounts attributed to both the public and private sectors for the years 1970-76. Damage repairs, including construction and maintenance costs, by the Department of Transportation are generally the highest single yearly expense. Several sources indicated that costs of preliminary design and engineering work and inspection, which are not routinely included in quoted construction costs, are almost 15 percent of the construction cost. This amount has been added to repair costs for each yearly total. Extensive federal funds were expended in 1972 to repair landslide damage caused by Hurricane Agnes.

Private costs for the 7-year period range from 15 to 45 percent of the yearly total. The 15-percent figure is for 1972, when additional public monies were spent owing to Hurricane Agnes. The yearly average of private costs is 31 percent of the total. Information regarding private expenses were provided almost exclusively by seven private consulting engineering and geology firms. More extensive participation by other such firms would have resulted in a more complete account of costs and a higher yearly total. Note that the estimated costs of damages provided by consultants is the same amount for each of the years 1970-72. This is a result of all seven consulting firms estimating that the costs of landslide damages were the same or in the same range for those years.

This study, limited in both time and in the number of sources contacted, indicates that an average of nearly $2.2 million per year is spent in Allegheny County owing to landslide damage. Studies of the San Francisco Bay region (Taylor and Brabb, 1972; Taylor and others, 1975; and this report) have shown that preliminary documentation of economic loss due to landslide damage may be less than half the actual total. This is likely true for Allegheny County, and landslide damage probably costs the public and private sectors there an average of at least $4 million per year.

If the $2.2 million figure is divided by Allegheny County's 1975 population of 1,605,016, the annual per capita cost of landslide damage is $1.35. Using the more realistic $4 million figure would raise this to $2.50 per capita per year.

"GEOTHERMAL ENERGY" BROCHURE

"GEOTHERMAL ENERGY," an introductory brochure on geothermal science and technology, is now available from the U.S. Department of Energy. The brochure includes information on the location of geothermal resources, on hydrothermal, geopressured and hot dry rock reservoirs, geothermal electric power generation, geothermal direct heat applications, environmental effects, and economic and legal considerations.

"GEOTHERMAL ENERGY" is available in limited quantities, without charge, to both individuals and organizations. Please write to: ENERGY, P.O. BOX 62, OAK RIDGE, TN 37830.

A SURVEY OF GEOLOGY STUDENTS

A recently issued report by the American Geological Institute entitled "Student Enrollment in Geoscience Departments 1979-1980" carries figures of student geology majors on a state-by-state basis, with a further breakdown of the figures according to men, women, and minority categories.

The figures listed for Pennsylvania colleges show a total of 1294 geology majors, consisting of 1006 undergraduates and 288 graduate students. Of the undergraduates, 881 (71%) were men and 258 (29%) were women. Of the graduate students, 125 (76%) were men and 30 (24%) were women. These figures follow the overall trend in the nation which shows 76% men and 24% women.

With reference to minority categories (American Blacks, Hispanics, American Indians, Oriental Americans) amongst student geology majors in Pennsylvania, the report shows a total of only 21 such students, equivalent to 1.6% of the total number of geology students in the state. Of the 21, there were 7 students at the graduate level. At the national level, of a total of 40,376 geology majors, only 2.5% were from the minority categories. These figures help to explain why so few from the minority categories appear on the geology lists of the Pennsylvania Civil Service Commission. We ought to do better!

The Abington-Cheltenham, Pa. Earthquake Sequence of March-May, 1980

by Richard E. Bischke

Beginning on March 2, 1980 and continuing thru the months of April and May, the city of Philadelphia and its northern suburbs were affected by a sequence of small earthquakes. The largest of these earthquakes occurred on March 5 and 11, had epicenters located near Abington, Pa., and had Nuttli Magnitudes of 3.5 and 3.7, respectively (Kafka and Bischke, 1980). Beginning on March 13 Lamont - Doherty Geological Observatory and Penn State University installed four portable microearthquake stations to monitor subsequent earthquake activity. One of these stations, located at the Naval Air Development Center in Warminister, Pa., recorded additional activity on April 10 (M=2.8), 16 (M=3.2), 25 and 30, and on May 2 (M=3.0), although these events have not been definitely confirmed.

Only one person living in Glenside, Pa. reported feeling the March 2 (M=2.8) foreshock whereas 1000's of people reported feeling the main shocks on March 5 and 11. These two earthquakes were both felt and heard, and people reported hearing explosive noises as if the oil or gas "heater blew up." The noise was described as a low distant rumbling sound, similar to distant thunder but building gradually in intensity and not fluxuating like the roll of thunder. During the March 5 earthquake, 100's of calls flooded the Cheltenham police station and the operator noticed that at first the Melrose Park, Pa. exchange lit up busy, followed by the Elkins Park, Pa. exchange, and later by exchanges located near Huntingdon Valley, Pa. The Abington and Jenkintown police also reported receiving numerous telephone calls, and police and fire departments were dispatched to check on possible explosions. About 13 minutes later, additional calls flooded the Abington, Jenkintown and Cheltenham police stations as people called to report the M=3.1 aftershock.

Following the March 5 earthquake, several local newspapers published an earthquake questionnaire, and students from Temple University helped distribute the questionnaire across the affected areas. Of these questionnaires, 317 and 485 were returned for the March 5 and 11 earthquakes respectively, and these felt reports were used to construct two Modified Mercalli Intensity maps (Figures 1 and 2).

People described both events as the passing of a subway train or of a heavy truck hitting a pothole or colliding with another object. In one case a plant overturned; in several cases small objects vibrated and shifted slightly on their foundations, plaster cracked and pictures tilted on the walls. In general, windows and dishes rattled, and over half of the people reporting the March 11 event at 1 in the morning were awakened by the earthquake. These reports generally place the maximum intensity at IV on the Mercalli scale for both the March 5 and 11 earthquakes, although intensity V occurred locally for both events (see Figures 1 and 2). Most people who felt the two main events reported that the March 11 earthquake was stronger than the March 5 earthquake, which is consistent with the magnitudes of the two earthquakes.

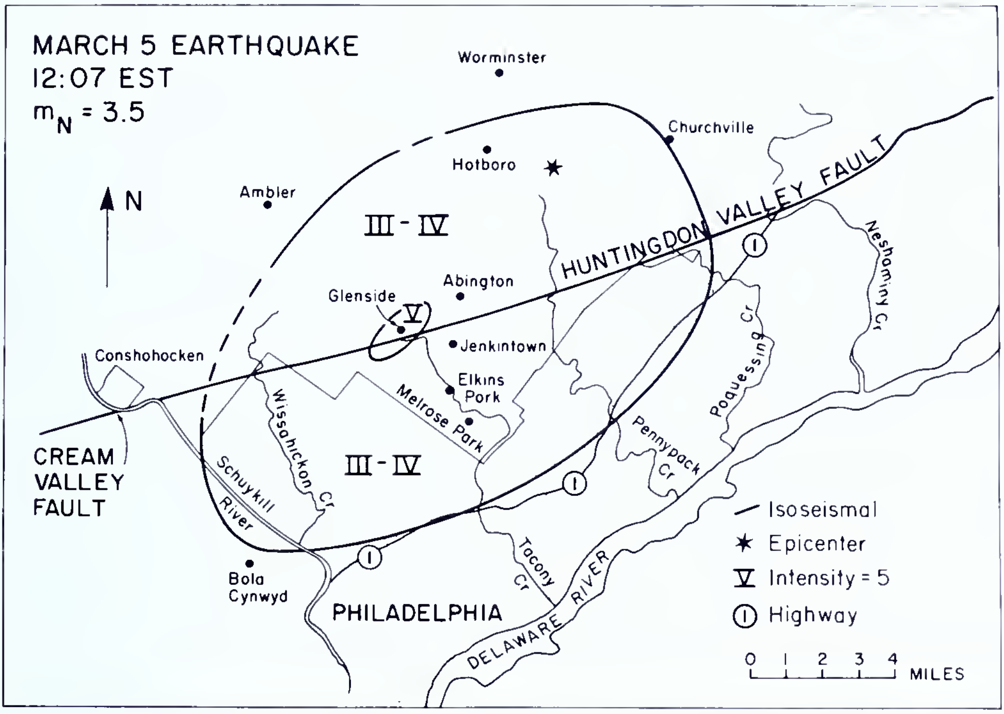


Figure 1: Isoseismal map of the March 5, 1980 Earthquake. An Isoseismal is a line of apparent equal intensity of ground shaking. The Maximum Intensity is V and the Isoseismal is dashed where uncertain. Note that the Isoseismals follow the general trend of the Huntingdon-Cream Valley fault line. The epicenter was determined by the Lamont - Doherty Geological Observatory in Palisades, New York.

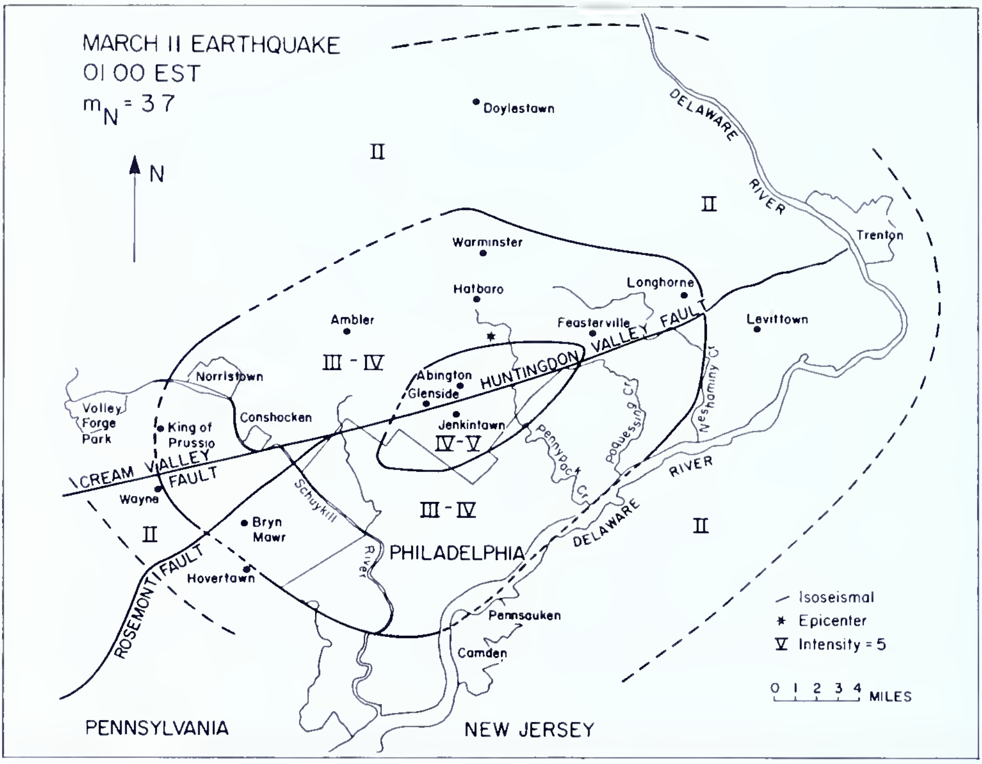


Figure 2: Isoseismal map of the March 11, 1980 Earthquake. The largest ground shaking lies within the IV - V Isoseismal zone. Also consult the explanation in Figure 1.

There are several lines of evidence which suggest that these earthquakes occurred on the Huntingdon Valley fault which runs thru the Glenside, Jenkintown, Abington, and Huntingdon Valley areas (Figures 1 and 2). First, the police departments which adjoin the fault zone reported the largest number of calls, and the highest intensities straddle and are roughly parallel to the fault zone (Figures 1 and 2). Secondly, the density of felt reports per unit area was largest in the Glenside, Jenkintown, Abington communities, although our data collecting process biases the number of returns coming from these areas. Lastly, the epicenters of all the earthquakes lie just to the north of the Huntingdon Valley fault zone. However, uncertainties as to crustal velocities in this region introduce several km's error in the epicentral determinations. Thus the Huntingdon Valley fault seems to have been responsible for at least the March 2, 5 and 11 earthquakes. This fault separates the paleozoic Wissahickon schists on the south from the Pre-Cambrian rocks to the north and represents a major tectonic dislocation extending for a distance of 78 km. The fault is vertical at the surface and brecciated serpentinites crop out just south of the fault line (Tearpock and Bischke, 1980). A pronounced fault valley with over 100 ft. of local relief typifies the fault line and offsets the Schuylkill, Wissahickon, Tacony, Pennypack, Poquessing and Neshaminy Rivers. This indicates a zone of structural weakness.

Although the east coast and particularly the Philadelphia region is not known for its earthquake activity, the area appears to be more seismically active than is generally realized. Earthquakes occurred in Philadelphia on Oct. 30, 1763, Mar. 17 and Nov. 29, 1800, Jan. 8, 1817 and on Nov. 11 and 14, 1840. These earthquakes originated in the Philadelphia area and either shook the city and/or agitated the Delaware River (Conrad and Geyer, 1971). These earthquakes were not studied and it is not known which fault or faults were responsible.

It now appears that the Huntingdon Valley fault should be classified as an active (intraplate) fault. Historical records collected from China, Japan and the Middle East indicate that active faults located within the interior or intraplate portions of the lithospheric plates tend to be smaller and occur much less often than earthquakes which are located on plate margins, such as California (Shimazaki, 1976). These intraplate earthquakes recur on the order of 1000 years and thus the historical record of eastern earthquakes is much too short to determine earthquake risk in any particular area. It is known, however, that very large intraplate earthquakes struck New Madrid, Missouri in 1811-1812 and Charleston, South Carolina in 1886 which is in a similar geologic environment. Furthermore, the magnitudes of earthquakes often correlate with the length of ground rupture (Wyss, 1979). The Huntingdon Valley fault and its continuation, the Cream Valley fault, extend for a total distance of 78 km. Thus (by this line of reasoning) the largest possible earthquake which could occur along this continuous fault line could be as large as $M \sim 7.0$ (see Wyss, 1979). However, even a fault rupture of 10 kms can generate a large earthquake. Thus the risk of a major earthquake in this area at some future time seems possible, although the probability of a large earthquake occurring during one's lifetime is very small. As 8 million people live in the greater Philadelphia region it seems warranted that additional study be given to this major tectonic dislocation.

Acknowledgements

A. Kafka, E. Schllesinger, V. Sakovich, H. Bart, and A. Bacon contributed significantly to the understanding of these events.

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SURVEY ANNOUNCEMENTS

ICE AGE BORDER IN PENNSYLVANIA MAPPED

For 185 miles across Pennsylvania from Potter to Northampton Counties, there stretches a belt of glacially deposited rocks which marks the border of the last great ice age of North America. This distinctive belt of rocks is described in the Pennsylvania Geological Survey's newly published report "Glacial Border Deposits of Late Wisconsinan Age in Northeastern Pennsylvania," authored by Professor George H. Crowl of Ohio Wesleyan University and by Dr. William D. Sevon of the Pennsylvania Survey.

With a full-color geologic map (at a scale of 1:100,000) and a 68-page text, the report fully describes the physical and environmental characteristics of the glacial sediments, as well as the economic potential of some of the accompanying sand and gravel deposits. The report will be of interest and benefit to land use planners, local government officials, geologists, developers, and all those interested in glacial processes and resulting landscapes.

General Geology Report 71, "Glacial Border Deposits of Late Wisconsinan Age in Northeastern Pennsylvania" is available from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125. The price is $9.20 (plus 56¢ sales tax for Pa. residents). Check should be made payable to the Commonwealth of Pennsylvania.

CENTRE COUNTY SUBSURFACE WATER RESOURCES

A comprehensive description and an inventory of Centre County subsurface water resources has been published by the Pennsylvania Geological Survey entitled "Summary Groundwater Resources of Centre County, Pennsylvania." The 60-page report with large full colored map was prepared by Charles R. Wood as part of a cooperative program with the Water Resources Division of the U.S. Geological Survey.

Centre County is one of the fastest growing counties in the state and an adequate water supply is the most basic requirement for such expansion. Groundwater constitutes one of the largest reserves of quality water remaining to be developed.

(continued)

The new Centre County groundwater report will be of great benefit to the planners, local officials, industry, and all persons concerned with an adequate water supply.

Water Resource Report #48, Summary Groundwater Resources of Centre County, Pennsylvania is available for $8.80 (plus 53¢ sales tax for Pa. residents) from the State Book Store, P.O. Box 1365, Harrisburg, PA 17125.

MINERALOGY OF BURNING ANTHRACITE DEPOSITS

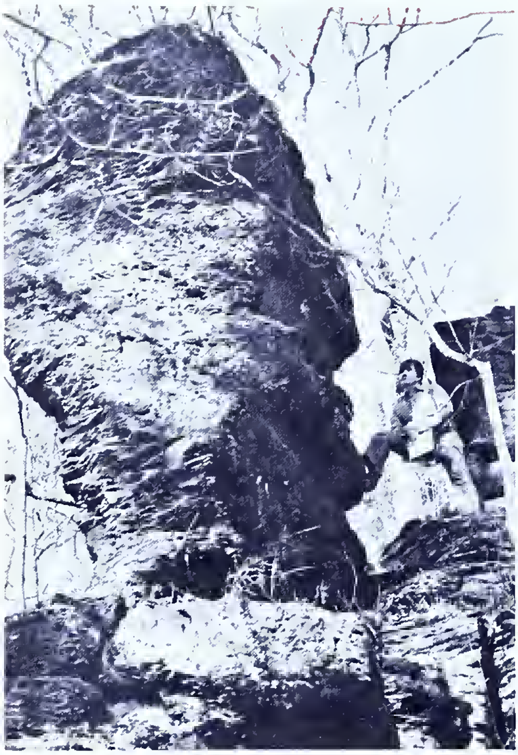
The Pennsylvania anthracite industry, which fueled the industrial revolution in this country, also left a legacy of scarred landscapes and of waste piles and culm banks. Some of these waste piles contain various amounts of fine-grained coal; in some localities the heat resulting from oxidation of the waste pile constituents has caused them to catch fire. There are places, also, where the unmined coal seam itself has caught fire, either from a burning overlying culm bank or from an accidental event in the mine itself. The burning culm banks and coal seams have given off gases which rise to the surface where they have formed distinctive and often unique new mineral occurrences.

Mineral Resource Report 78, "Mineralogy Associated with Burning Anthracite Deposits of Eastern Pennsylvania" has been published by the Pennsylvania Geological Survey. The illustrated, 82-page report was co-authored by Dr. Davis Lapham (now deceased), John Barnes, Wayne Downey, Jr., and Robert Finkleman. The report details the results of the cooperative research investigation, including detailed analyses and descriptive data. Nineteen minerals never before found in Pennsylvania are described, including six that are unnamed. One totally new mineral species has been described as an outgrowth of this investigation and lively debate developed in this profession as to what constitutes a valid new mineral. This study has stimulated research on the bituminous waste pile of western Pennsylvania.

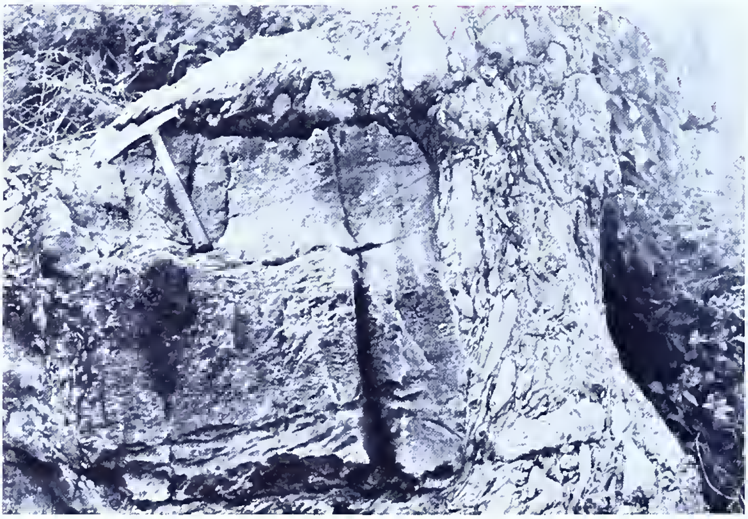
It is anticipated that this report will be of particular use to environmentalists, mineralogists, and many others, including those interested in the revitalization of the anthracite industry, restoration of mined land, and the gasification of coal as a new source of energy.

Mineral Resource Report 78, "Mineralogy Associated with Burning Anthracite Deposits of Eastern Pennsylvania" can be ordered from the State Book Store, P.O. Box 1365, Harrisburg, Pa. 17125. The price is $2.30, (plus 14¢ sales tax for Pa. residents). Checks should be made payable to the Commonwealth of Pennsylvania.

pennsylvania geopics



Sentinel Rock, a 25-ft high pinnacle of Brunswick red shale (Triassic) located on the east bank of Tohickon Creek in Nockamixon State Park, Bucks County. This impressive rampart was formed by differential weathering along planar joints and irregular curved features. Photo courtesy of Jon D. Inners.



Limestone breccia in the Conestoga Formation in a small abandoned quarry about 700 feet south of Mackley's Mill, Hellam, York County, Pennsylvania. This chaotic mass of angular and subangular blocks is part of a large submarine slide that piled up at the base of a steep Cambro-Ordovician carbonate bank. The large block on which the hammer rests is 2.5 feet square. Photo by Jon D. Inners.

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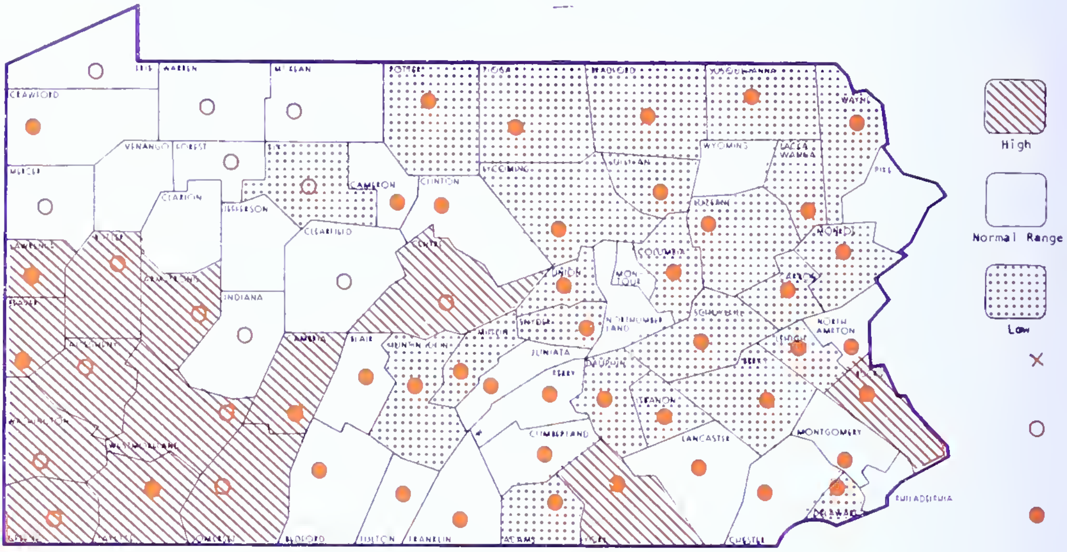

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TOPOGRAPHIC AND GEOLOGICAL SURVEY
Arthur A. Socolow, State Geologist

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ON THE COVER: Blue Rocks Block Field, located two miles northwest of Lenhartsville, Berks County. A narrow, boulder glacier over half mile long; formed by slow, gravity movement of the boulders down the southern slope of Blue Mountain during the glacial climate of the region.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania, 17120.

Editor, Arthur A. Socolow; Associate Editor, Donald M. Hoskins.

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DECEMBER 1980

FROM THE DESK OF THE STATE GEOLOGIST

GEOLOGY, HEADLINES, AND PENNSYLVANIA

Geology and geologic events have in the past couple of decades made the headlines in many ways: as scientific break-throughs with the recognition of the Earth's plate movements; as major-resource traumas with the difficulties of Mid-East oil; as the joyous observation of the astronauts collecting rock specimens on the moon; as the recent tragic Italian earthquake and the awesome eruptions of Mt. St. Helens.

Pennsylvania geology has not had any comparable media events, for which we should probably be thankful. Yet, lest anyone feel that the "arena" of geology in our state is without its episodes and its challenges, let me assure otherwise. From both the standpoint of energy resources and geologic structural interpretation we have the real challenge to determine whether the suggested overthrust belt of eastern Pennsylvania is real or fictional; and if real, is there recoverable oil or gas beneath the thrust sheets. Our Commonwealth energy inventory also carries with it a challenge for geologists to move beyond the numerical calculations of our coal reserves, on to practical determination of composition, depths, and structural conditions which will result in accelerated development of our coal.

Pennsylvania's geologic crises, thankfully not creating human tragedies like recent events elsewhere, are nevertheless, serious, with real economic and personal impacts. The drought in eastern Pennsylvania has had a major effect on the ground-water resources, causing thousands of wells to be depleted and forcing the Delaware River Basin Commission to declare one geologic terrane of the region as a "groundwater-protected area." This poses a challenge to our hydrogeologists to better delineate the groundwater resources of our state, so as to protect the deficient geologic formations and better develop the abundant groundwater areas.

And still on the subject of geologic crises is the continuing need to delineate the landslide areas of western Pennsylvania which annually result in millions of dollars of property damage (see last issue of this bulletin). Of course once we plot all the landslide and sinkhole areas, we hope the officials and decision makers will use the information to protect the public.

Geology, mineral and energy resources, and geologic hazards are daily elements in the lives of all Pennsylvanians. That is sufficient challenge for us to press on with our geologic efforts and responsibilities.

Arthur A. Socolow

Triassic Fossil Reptile Footprints Near Coopersburg, Lehigh County, Pennsylvania

by J. Donald Ryan
Lehigh University

Early in 1978, James Turner, at that time a resident of Bethlehem, PA., noticed a large outcrop of gently dipping red shales in a tractor-trailer parking lot along the east side of Route 309 just south of the village of Coopersburg in Lehigh County. The site is located exactly 0.4 miles south of Station Avenue in Coopersburg and exactly 0.1 miles north of the Lehigh County-Bucks County line (see Figure 1). Much of the soil at the site had been removed exposing bedding planes in the underlying rock. Mr. Turner, an amateur fossil collector who had taken several courses in geology at Dickinson College, could not resist; he pulled over to the side of the road, left his car, and searched for fossils. He found what he thought might be several fossil footprints. Recognizing the potential importance of the prints, he carried specimens to Donald Hoff, curator of the William Penn Museum in Harrisburg, and to the author for confirmation. Both agreed that the specimens indeed were fossil footprints, probably reptilian. The author, who was contacted in September 1978, then suggested that some of the students of Lehigh University might be interested in assisting Mr. Turner in a "dig" at the site to see if additional specimens could be found. A number of students volunteered and spent many hours working on the project. Michael Clinch, Susan Gawarecki, and Steven Perry were particularly active. The group was able to uncover a large number of additional prints in varying sizes, in varying states of preservation. The smallest tracks are 2 - 3 centimeters in length—the largest are 10 - 12 centimeters in length.

In November, Dr. Donald Baird, Director and Curator, Natural History Museum, Princeton University, visited the site and identified at least four types of prints. These are prints of 1) the three-toed prosauropod dinosaur *Anchiosauripus* (see Figure 2), 2) the four-toed crocodile-like armored phytosaur *Rutiodon*, 3) *Chirotherium* also a four-toed reptile but of uncertain affinities (possibly a dinosaur "cousin"), and 4) the tiny lizard *Rhyncosauroides brunswickii*, first described by Willard and Ryan from exposures at Kintnersville, Bucks County, Pennsylvania.

Dr. Baird also noted other prints which need further study before identification is possible. There may also be some undescribed prints at the site.

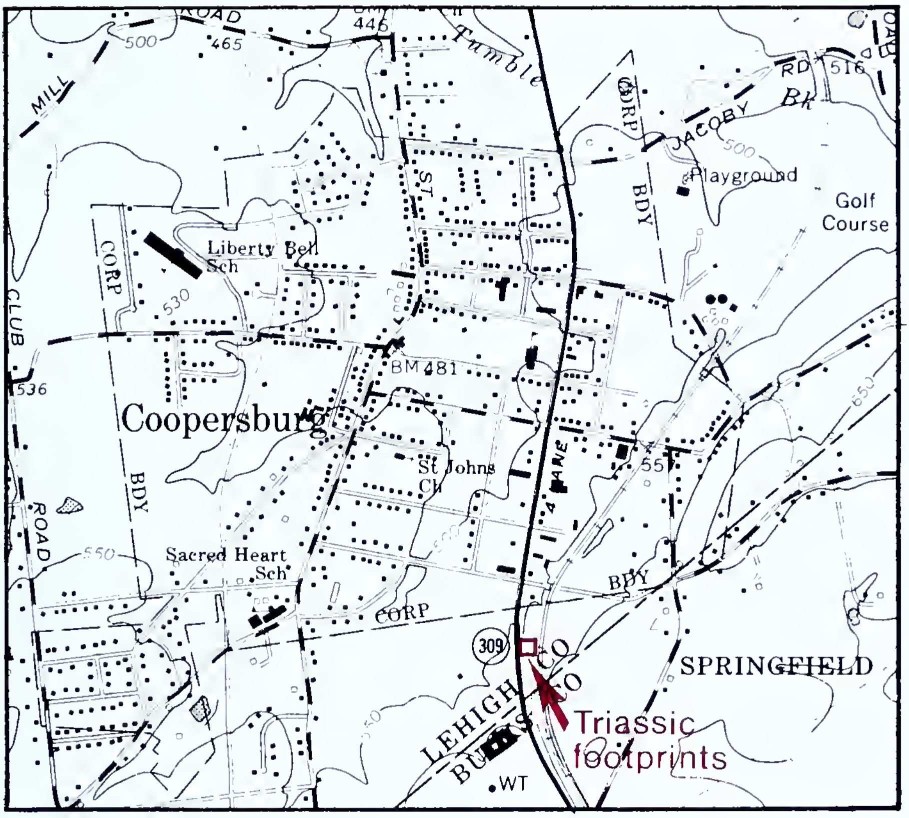

Figure 1. Map showing location of Coopersburg, Pa. Triassic fossil footprint locality. From U.S.G.S. Allentown East 7½′ quadrangle.

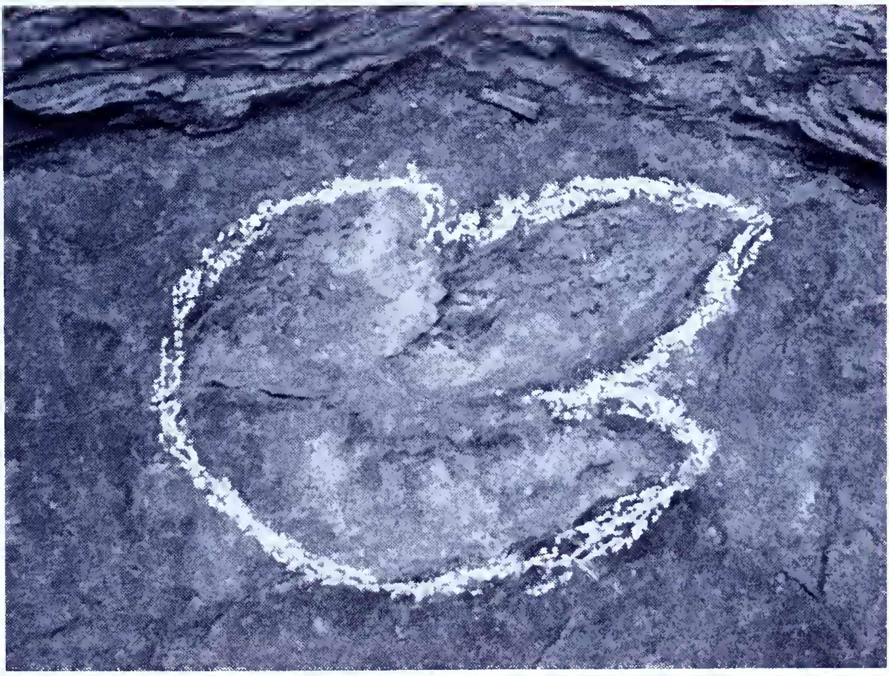

Figure 2. *Anchiosauripus* footprint in the Brunswick Formation, Coopersburg, Pa. Print outlined with chalk. Length of print about 12 cm.

The tracks occur in red mudstones fairly close to the top (within a few tens of meters) of the Brunswick Formation of the Newark Supergroup a short distance to the southeast of outcrops of the well-known Brunswick fanglomerates which are found along the "Border Fault" (see Wood, et al., 1972, Water Resources of Lehigh County, Pennsylvania, Water Resource Report 31, Pa. Topo. & Geol. Survey). Interestingly, this is at about the same stratigraphic level at which *Rhyncosauroides brunswickii* occurs at the type locality in Kintnersville, Bucks County, along the Delaware River.

In recent years, it has been shown that the Brunswick Formation, traditionally considered to be Upper Triassic in age, is in places partly Jurassic age. The fossil footprint suite at Coopersburg appears to confirm an Upper Triassic age (Rhaetian stage) for the containing rocks at Coopersburg (see Olsen, Paul E., 1980, Triassic and Jurassic Formations of the Newark Basin, in Guidebook, 52nd Annual Meeting of the New York State Geological Association, Warren Manskeizer, editor). The Brunswick Formation outcrops at Coopersburg, therefore, are stratigraphically equivalent to the recently proposed Passaic Formation by Olsen in New Jersey.

groundwater hydrology of the williamsport metropolitan area on open file

A detailed study of the groundwater availability of the greater Williamsport metropolitan area was completed recently by Orville B. Lloyd, Jr. and Louis D. Carswell and is scheduled for publication in mid-1981. The study is based on well records and pump tests of all the rock and unconsolidated aquifers in the area. Both the quantity and quality of the groundwater in each aquifer is discussed. Complete well and spring records and chemical analyses are included. A full-color geologic and hydrologic map of the entire area, as well as a water-table map of the valley-fill deposits, highlight the report. A comprehensive, explanatory legend enables the reader to easily interpret the maps.

This report is now available for inspection prior to publication at the Pennsylvania Geological Survey, Editorial Section, 9th Floor, Executive House, Harrisburg, PA.

MELTWATER EROSION IN SALEM CREEK VALLEY, LUZERNE COUNTY, PENNSYLVANIA

by Jon D. Inners
Pa. Geological Survey

Meltwater channels are the sluiceways that carry off water directly from wasting glacial ice. Generally their courses follow pre-existing stream valleys that slope away from the glacial margin (Embleton and King, 1975). Characteristically such channels (1) show evidence of having once transmitted considerably more water than they presently do, (2) occur within or immediately outside glaciated terrain, and (3) exhibit either extensive waterlaid depositional landforms or striking erosional features. Probably the easiest recognized channels are those that lie directly downstream from either glacial end moraines or recessional moraines. The major control on whether depositional or erosional features dominate is the size of the valley. In wide valleys meltwaters spread out, lose velocity, and deposit their sediment load as gravelly valley trains. In narrow valleys, however, where the meltwaters are concentrated to flow at high velocity, erosion rather than deposition takes place. The volume of water in meltwater channels is subject to great daily and seasonal fluctuations. Not surprisingly, the highest levels are attained during summer days and the lowest on winter nights.

The relationship of terminal ice position to meltwater channels is clearly shown in the vicinity of Berwick, northeastern Pennsylvania (Figure 1). In this area the Woodfordian (Late Wisconsinan) continental glacier reached its maximum extent along an irregular northwest-southeast front that trended diagonally across the North Branch, Susquehanna River, valley between Lee and Nescopeck Mountains. From this advance position the surface of the ice sloped upward toward the northeast at a gradient of about 600 ft/mile near Lee Mountain and 80 ft/mile near Nescopeck Mountain (Inners, 1978; Crowl and Sevon, 1980). Within the area bounded by these two mountains, numerous streams served as sluiceways for meltwater from the glacier. From north to south the most important were Salem Creek on the north side of the Susquehanna, the Susquehanna River itself, and Wapwallopen Creek and two unnamed tributaries of

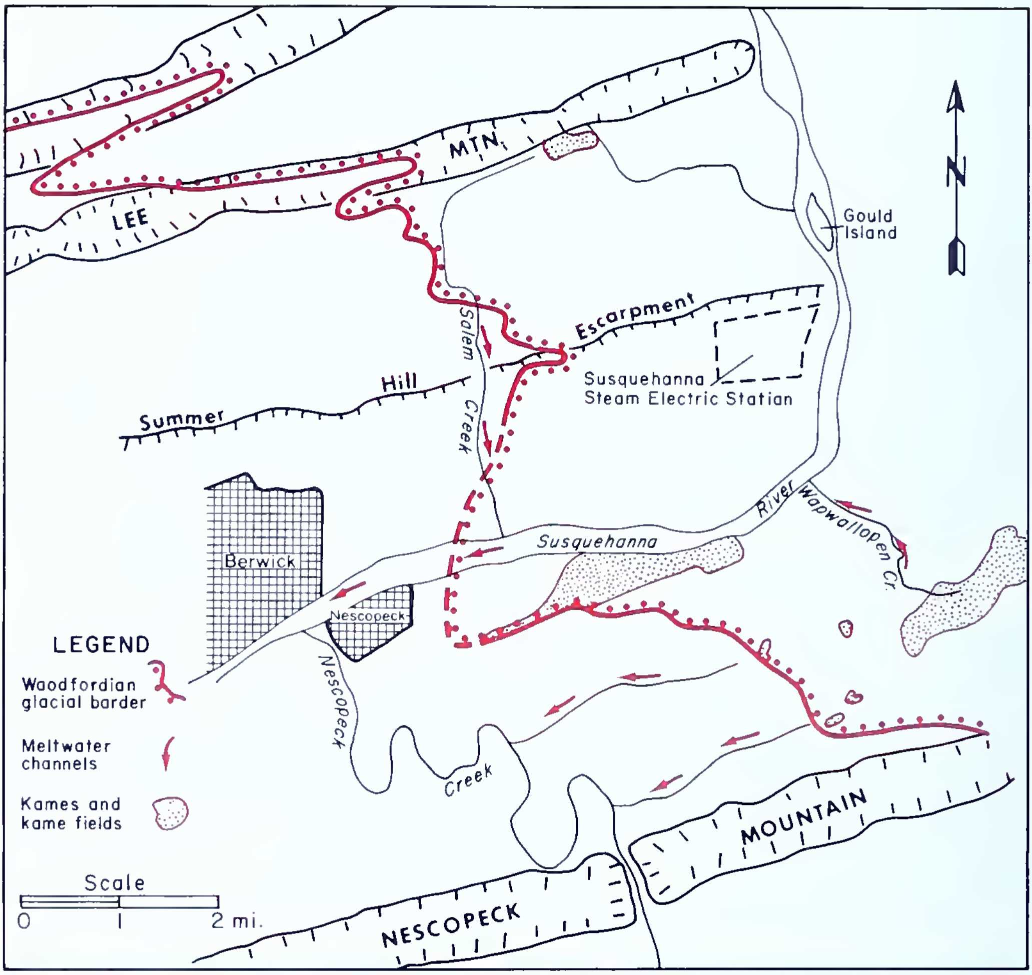

Figure 1. Woodfordian glacial border in the vicinity of Berwick, northeastern Pennsylvania (modified from Crowl and Sevon, 1980), showing location of major meltwater channels.

Nescopeck Creek on the south side of the river. The heads of the major meltwater streams are commonly marked by kames or kame fields along the margin (or a short distance behind the margin) of the Woodfordian moraine (Inners, 1978; Crowl and Sevon, 1980). The association of ice-contact features with preglacial stream valleys suggests that these old valleys became the loci of considerable meltwater flow very early in the history of deglaciation. Of the discharge channels named, only the Susquehanna River, far and away the largest of these features, is characterized by major deposition of outwash gravel. The channelways which to the writer's knowledge show the greatest amount of meltwater erosion are Wapwallopen Creek and Salem Creek. Particularly good examples of scour features are evident along the latter stream.

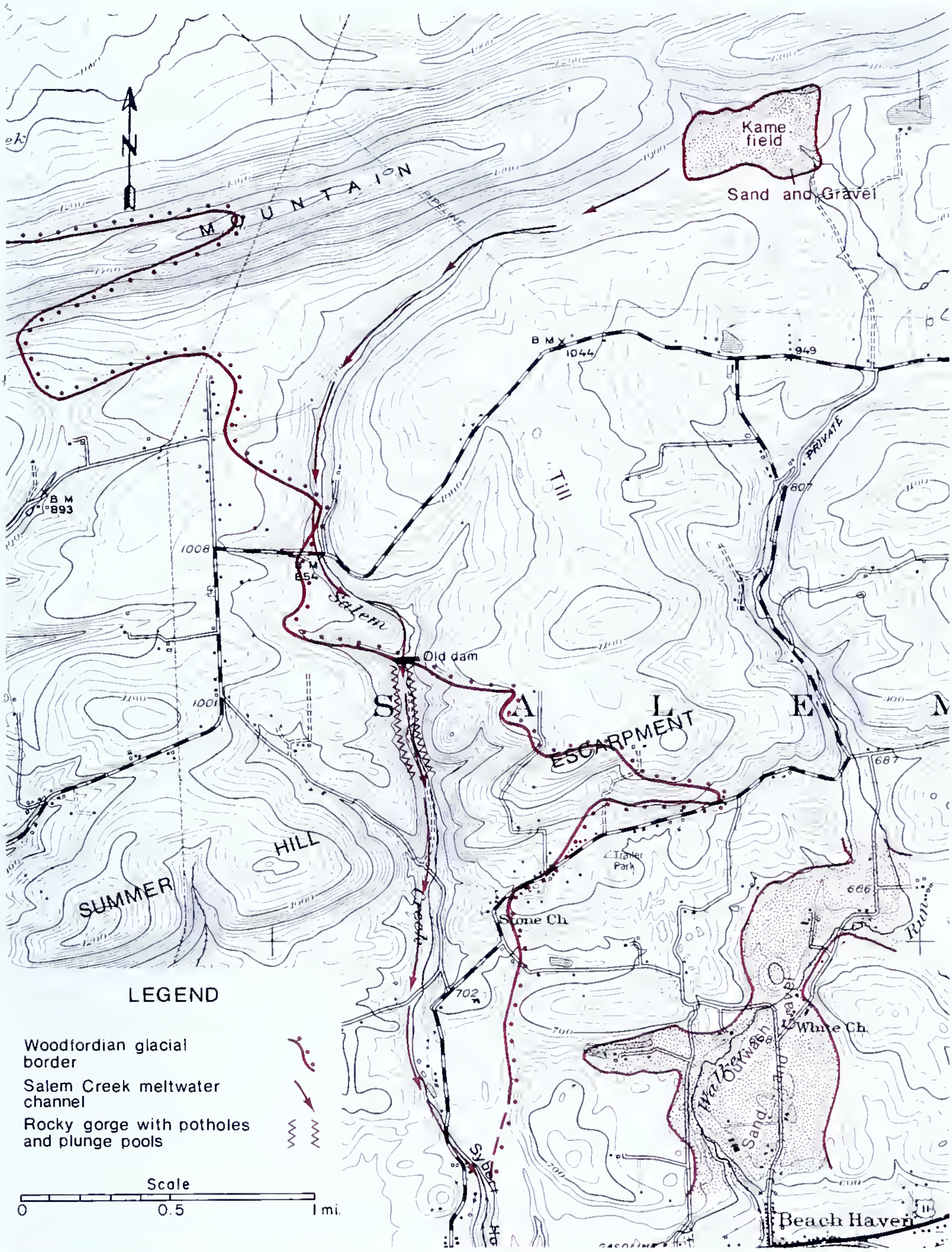

Figure 2. Generalized surficial geologic map of Salem Creek area (after Inners, 1978). Note deeply incised nature of valley north of Summer Hill escarpment.

Salem Creek is located about 2 miles northeast of Berwick in Salem Township, Luzerne County. The stream rises in a poorly drained, swampy area on the south side of Lee Mountain and forms a rather deep gorge through resistant rocks of the Catskill and Trimmers Rock Formations north of the Summer Hill escarpment at Stone Church (Figures 2 and 3). South of the escarpment relief along the stream is relatively subdued, except along its last 0.5 mile where it descends through Sybert Hollow to reach the level of the Susquehanna River. Total length of the creek is about 5 miles. Prior to the Woodfordian glaciation, Salem Creek probably headed in a deep notch on Lee Mountain about 0.4 mile north of its present source. Stream derangement in the vicinity of a 60 acre kame field has resulted in loss of this headwater area to a shorter stream that drains in a generally eastward direction to a junction with the Susquehanna opposite Gould Island, about 1.3 miles north of the Susquehanna Steam Electric Station.

The Woodfordian glacial border crosses Salem Creek about 2.3 miles above its mouth and trends northward parallel to the creek for

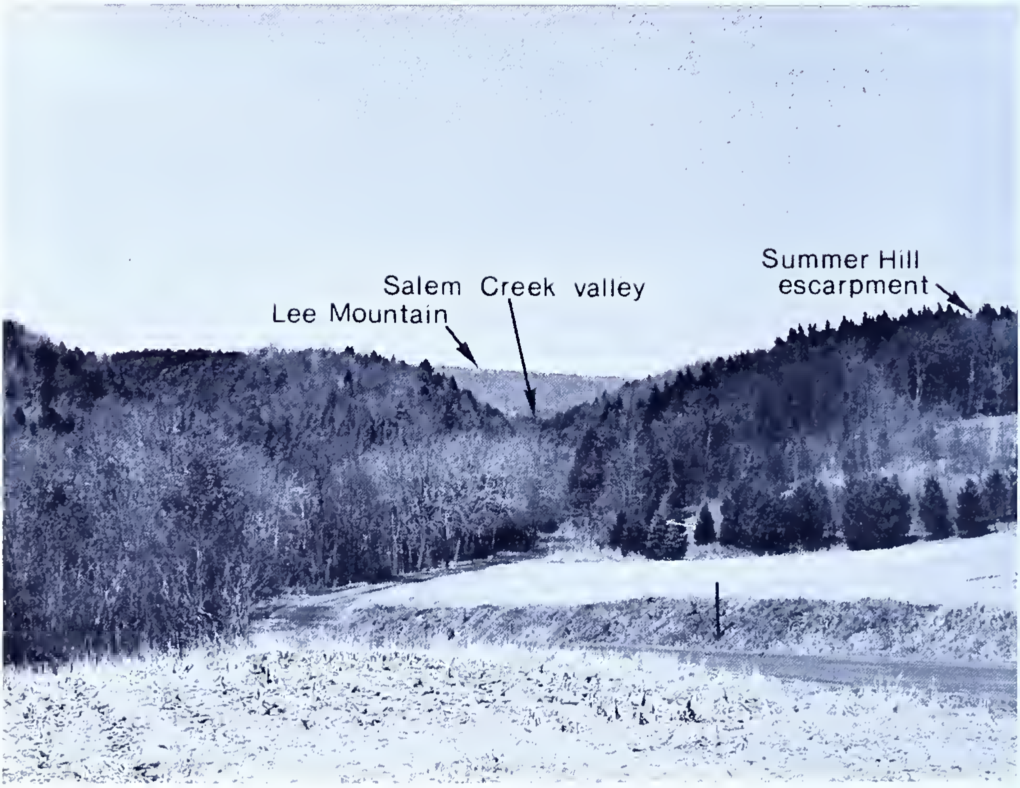

Figure 3. Salem Creek valley, looking north through gap in Summer Hill escarpment toward Lee Mountain.

about 1.4 miles to the base of Lee Mountain (Figure 2; Inners, 1978). Deposits associated with the Woodfordian border consist mainly of bouldery glacial till, surficial exposures of which are very abundant along L.R. 40028 (the road to Split Rock Farm) east of the creek. The large, pitted kame field just east of the head of Salem Creek is composed predominantly of stratified sand and gravel.

Although glacial meltwaters coursed down the entire length of Salem Creek during the early stages of Woodfordian glacial stagnation and retreat, the most spectacular evidence of meltwater erosion is found in a 1500 ft. reach immediately south of the glacial border at the old Berwick Water Company dam (Figure 2). Within this portion of the valley are several large potholes and/or plunge pools up to 15 ft. in diameter and 10 to 15 ft. deep that are scoured out of north-dipping Trimmers Rock siltstone and sandstone. Some of the potholes were formed by the coalescing of smaller erosional depressions. Although a few of these features may have been wholely circular pits that were later breached by stream downcutting, the larger ones may have been simply scoured into the bedrock walls of the channel by stationary eddies in the stream current. Probably the most impressive of these scour features is a conspicuous, smooth-walled "amphitheater" 6 ft. high, 9 ft. wide, and 4.5 ft. deep (into the hillside) situated on the east side of the valley about 1500 ft. downstream of the old dam (Figure 4). Other good examples of meltwater erosion include what appear to be large plunge pools on the west side of the valley at the old dam and at a small weir 1000 ft. downstream (Figure 5). Numerous large potholes also occur in a narrow, rocky gorge just below the weir.

The Salem Creek meltwater channel was activated when the Woodfordian continental glacier reached its terminal position about 15,000 years ago. At first meltwaters poured down the valley as active glacial ice continued to move forward to a stillstand position. Most of this water probably originated from melting at or near the front of the glacier. Once stagnation of the terminal zone of the ice set in, however, an active subglacial stream was initiated in the pre-existing stream valley, its head in an area of crevassed and rotten ice (now represented by the kame field) about 2 miles northeast of the glacial border. This area of collapsed ice served as a sump for numerous streams which flowed on and within the glacier. As the ice downwasted and backwasted over a period of tens or even hundreds of years, a steadily decreasing volume of meltwater cascaded down Salem Creek, subject to marked daily and seasonal variations.

Although the meltwater was undoubtedly heavily laden with sediment, the normally large volumes of water and the narrowness of the valley combined to flush most of the sediment out into the broad Susquehanna valley where it became part of the great North Branch valley train. As the sediment-charged waters poured over bedrock ledges and eroded laterally into the steep walls of the valley, deep plunge pools, potholes and furrows were carved into the resistant rocks north of the Summer Hill escarpment. With continued downcutting of the stream, some of these features were breached or partially obliterated. It is probable that active bedrock erosion along Salem Creek virtually ceased after final melting of ice in the

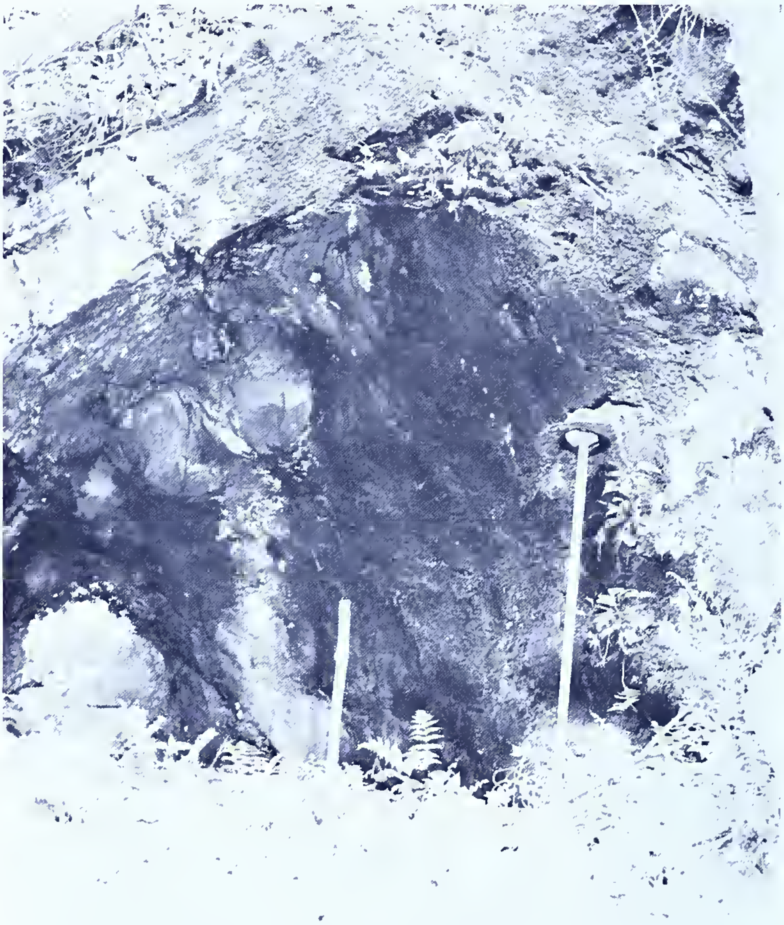

Figure 4. Polished, erosional "amphitheater" in Trimmers Rock siltstone on east side of Salem Creek, about 1500 ft. downstream of old dam. Staff is 5 ft. long.

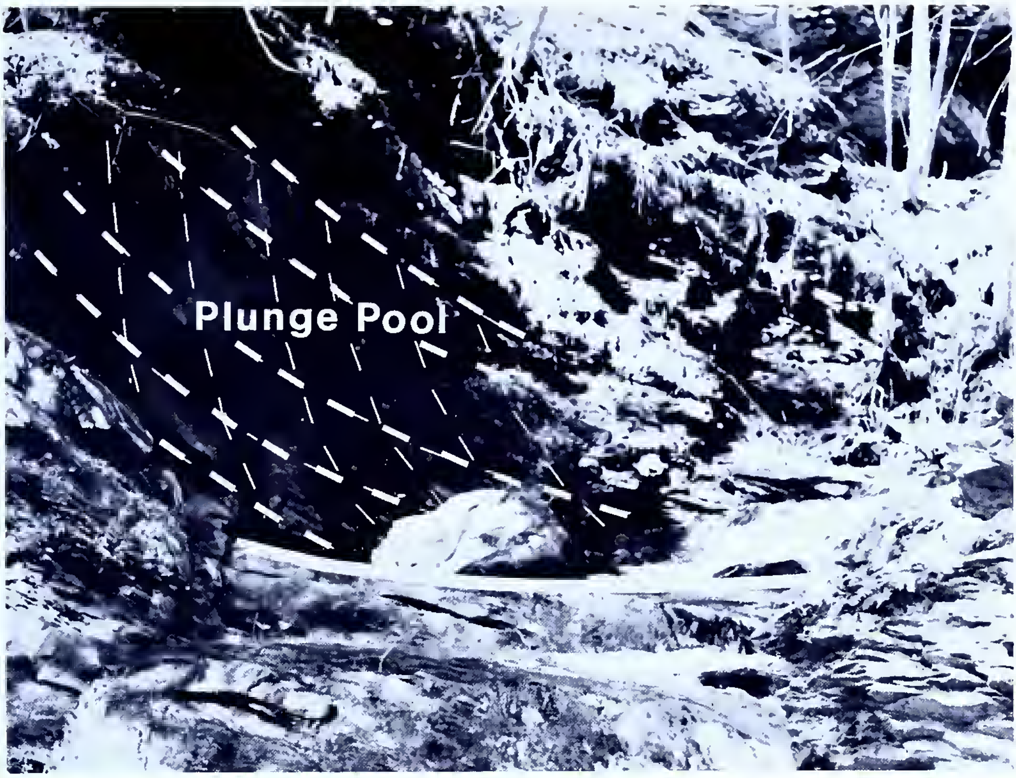

Figure 5. Large plunge pool or breached pothole located on west side of creek near concrete weir, about 1000 ft. downstream of dam. Feature—eroded into interbedded siltstone and shale of the Trimmers Rock Formation—is 10 to 12 ft. high on west (left) wall and 15 ft. in diameter. Large boulder lies in middle of smooth circular depression.

area and that the effects of recent erosion in the valley are relatively minor.

Even though Salem Creek in recent times does not approach its ancient magnitude, the stream is still capable of rising to destructive heights during periods of sustained runoff. One such flood episode occurred in the mid-1950's and resulted in the breaching of the 18 ft. high earth-rock dam of the Berwick (now Keystone) Water Company. Personnel of the Keystone Water Company (Berwick District) office report that the dam failed in mid-October, 1954, during rain storms spawned by Hurricane Hazel.

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Mineral Resource Division Chief Retires

Following a productive career with the Pennsylvania Geological Survey that spanned two decades, Bernard J. O'Neill, Jr. retired this past September, 1980. Most recently, Bernie served as Chief of the Mineral Resources Division, and over the years he completed a series of four extensive reports on Pennsylvania's clays and shales, two of the Commonwealth's most plentiful resources. Thanks to his efforts, the Bureau has chemical, mineralogic, and physical test results for 707 samples from across the State. Other major projects intended to assist the mineral industry include the popular "Directory of the Mineral Industry in Pennsylvania" and "Limestones and Dolomites of Pennsylvania."

Bernie first joined the Survey in 1962. Earlier, he had experience in a wide variety of minerals exploration and development projects for The New Jersey Zinc Company and the Foote Mineral Company. Among his accomplishments, he helped direct the difficult New Hartman shaft sinking at Friedensville. He graduated from the California Institute of Technology and Franklin and Marshall College after serving as an Army Air Corps pilot during World War II.

Bernie O'Neill and his wife, Betty, now plan to enjoy the relaxing climate of Florida. We at the Survey are proud to have had Bernie on our staff and wish the O'Neills well in all endeavors.

Ancient Eolianite (Wind-blown Sand) In Centre County

Thomas M. Berg
Pa. Geological Survey

While doing reconnaissance mapping in Centre County for the new state geologic map, an unusual, very light gray sandstone was found within the Mauch Chunk Formation. The Mauch Chunk is Mississippian in age (about 330 million years old). In the central part of Pennsylvania, the formation normally comprises buff, clayey sandstone interbedded with red siltstone and shale. In the southwestern and south-central parts of the state, the Mauch Chunk Formation also includes the Loyalhanna Member, which is strongly crossbedded, calcareous sandstone or sandy limestone. The Loyalhanna has been traced as a mappable member from Altoona along the Allegheny Front to Sullivan County (Wells, 1974, p. 84). The Loyalhanna Member north of Altoona is a greenish-gray, crossbedded, calcareous sandstone. It forms a low cliff which is easily traced on aerial photographs, making it an important mapping unit. It is about 50 feet thick.

At an inactive quarry about 4½ miles east of Snow Shoe, Pennsylvania, the sandstone at the stratigraphic position of the Loyalhanna Member is very much different from the Loyalhanna exposed elsewhere along the Allegheny Front. It is not greenish-gray, but is very light gray to almost white. Nor is it calcareous. Close inspection of hand specimens reveals well-sorted and rounded quartz grains that have frosted surfaces. The quartz grains display better-developed sphericity than in sandstones above and below the Loyalhanna. The rock is very friable, and individual sand grains can be rubbed off hand specimens with moderate finger pressure. The sandstone is crossbedded, and breaks up into platy and slabby pieces (Figure 1).

Microscopic examination of a thin section of this sandstone reveals that it is a supermature quartzarenite (following classification scheme of Folk, 1968). It is composed of quartz grains (Figures 2 & 3) that have an apparent bimodal size distribution and are either medium grained or very fine grained to coarse silt size. The quartz framework is set in a binder that is a combination of sericite (2.0%) and kaolinite (1.2%) matrix, authigenic quartz overgrowth cement (3.6%), and a composite of sericite and microcrystalline quartz cement (5.0%). There are many voids in the thin section, and they make up 6.6% of the rock volume. (Although the thin section was impregnated with cementing medium, some plucking of grains may have occurred because of the highly friable nature of the sandstone. This would somewhat increase the apparent void space.)

There are various interpretations for the origin of the calcareous sandstones of the Loyalhanna Member. They range from submarine sand waves to beaches and dunes (Wells, 1974, p. 84). The writer believes this noncalcareous, almost white facies of the Loyalhanna is attributable to a wind-blown dune environment, and that the sandstone can be tentatively described as an eolianite. The word "eolian" means "wind-blown." The crossbedding, low detrital clay content, good sorting (although bimodal), frosted and rounded quartz, lack of sedimentary and metamorphic rock fragments (which are less durable than quartz), and lack of heavy minerals all tend to point to an eolian environment of deposition. Allen (1970, p. 104) indicates that bimodal sorting can occur in interdune areas, even though most dune sands are unimodal. The finer mode in the bimodal sand was probably trapped in the "hoppers" between larger quartz grains.

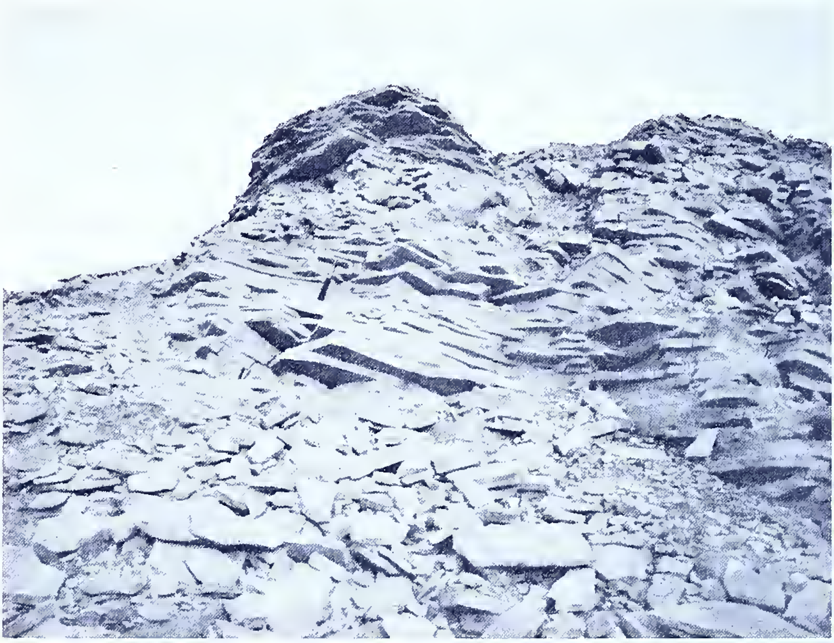

Figure 1. Outcrop of probable eolian sandstone in quarry at 41° 02′30″N/77°52′15″W in Snow Shoe SE 7½-minute quadrangle. Note large-scale cross-strata and slabby break-up of rock. Hammer gives scale.

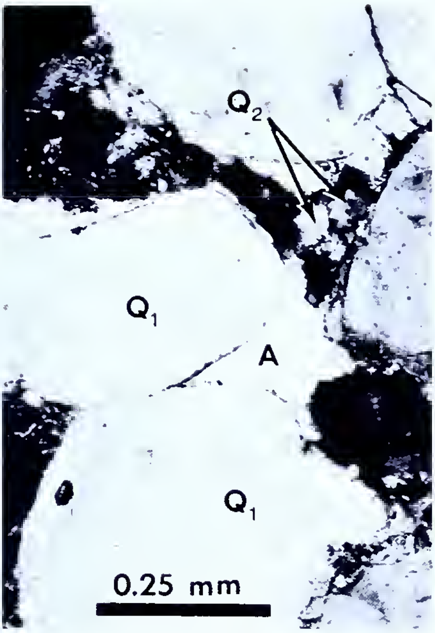

Figure 2. Photomicrograph of thin section of sandstone shown in Figure 1. Note rounded quartz grains of medium size (Q_1), quartz grains of coarse silt size (Q_2), and authigenic quartz overgrown (A). Crossed nicols.

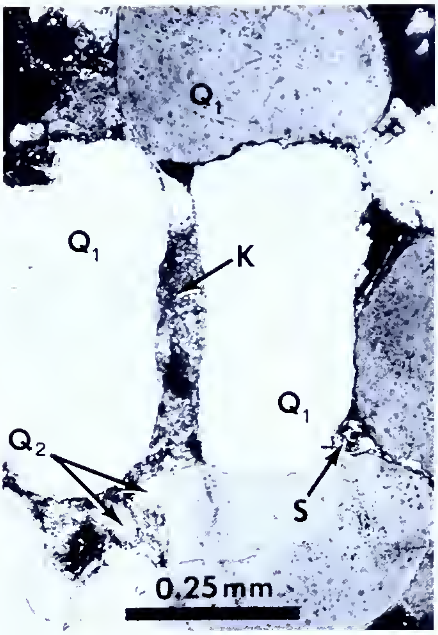

Figure 3. Photomicrograph of thin section of sandstone shown in Figure 1. Note rounded quartz grains of medium size (Q_1), quartz grains of coarse silt size (Q_2), pocket of kaolinite matrix (K), and small area containing composite sericite/microcrystalline quartz cement (S). Crossed nicols.

Further research on the Mauch Chunk depositional environments needs to be done, and this facies of the Loyalhanna Member, which may be an ancient eolianite, awaits detailed examination by students of sedimentology. Because this is one of the most quartz-rich and porous sandstones in the Mississippian and Pennsylvanian part of Pennsylvania's stratigraphic sequence, it may be of some economic significance either as a source of silica or as an aquifer. Our present knowledge of its lateral extent is very limited.

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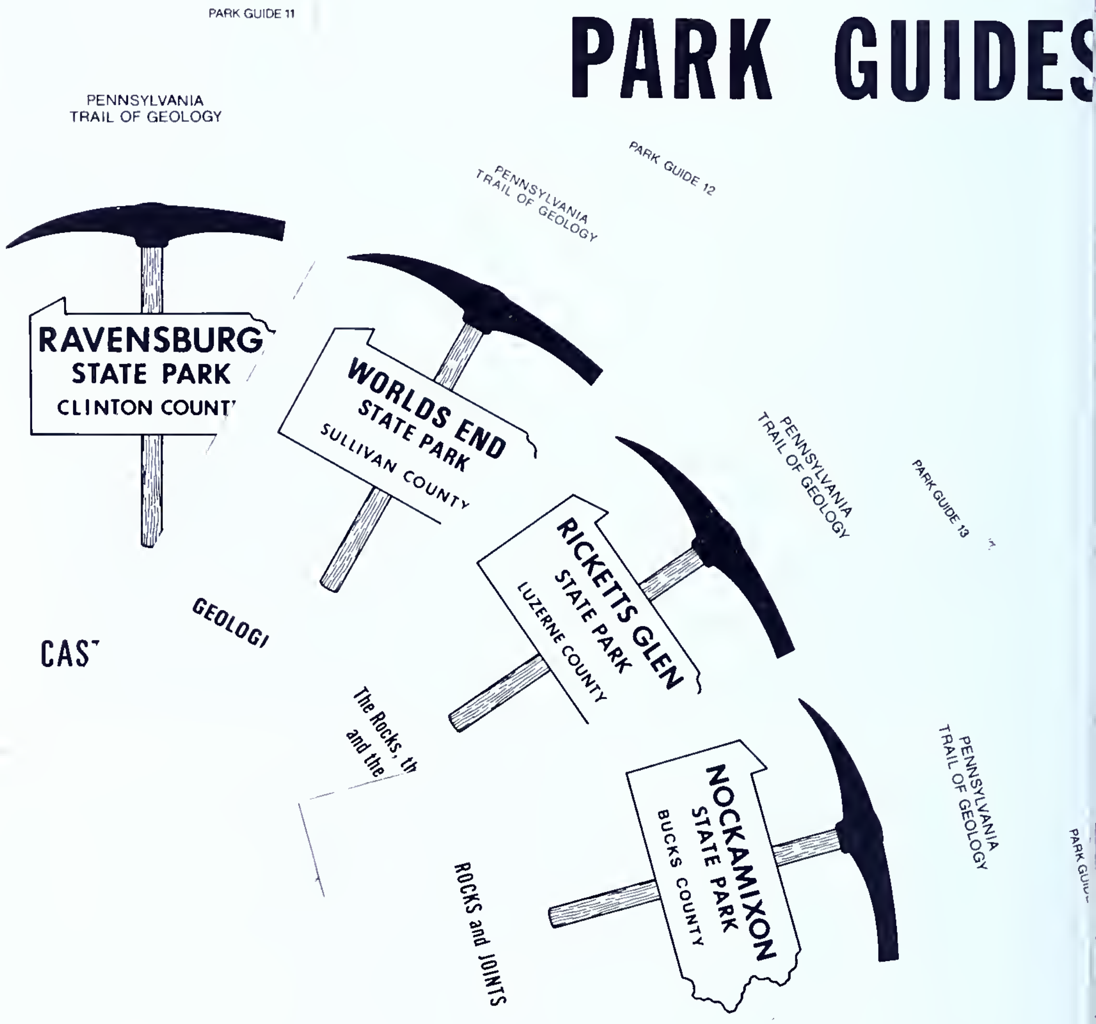
SURVEY PUBLISHES FOUR NEW PARK GUIDES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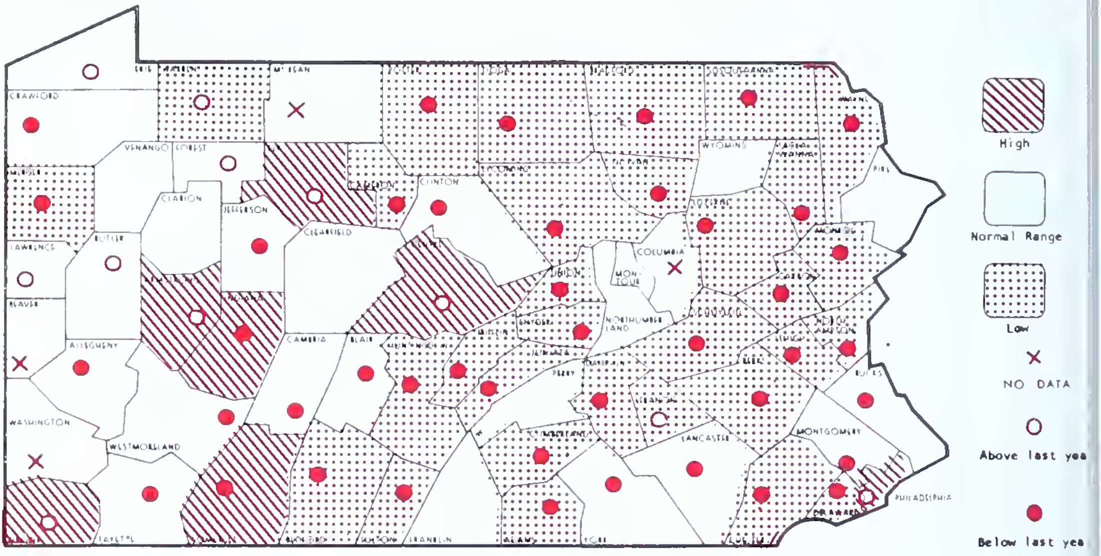

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